

**IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF OKLAHOMA**

STATE OF OKLAHOMA, *et al.*,

Plaintiffs,

v.

TYSON FOODS, INC., *et al.*,

Defendants.

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) **Case No. 4:05-cv-00329-GKF-PJC**
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Declaration of John P. Connolly, Ph.D., P.E., B.C.E.E.

I, John P. Connolly, state the following:

1. My name is John P. Connolly, and I am a Principal/Senior Technical Advisor for Anchor QEA, located in Montvale, NJ. Anchor QEA was compensated at a rate of \$348 per hour for the time I devoted to this project.
2. I hold a B.E. degree in Civil Engineering from Manhattan College, a M.E. in Environmental Engineering from Manhattan College, and a Ph.D. in Environmental Health Engineering from The University of Texas at Austin. I am a registered professional engineer in New York and Texas, a Diplomate by Eminence in the American Academy of Environmental Engineers and a member of the United States Environmental Protection Agency (USEPA) Science Advisory Board.
3. I have studied environmental chemistry as part of my graduate work and I taught chemical equilibrium modeling as a professor at Manhattan College. I have developed models of phosphorus cycling in lakes and have been involved in a phosphorus TMDL study in the Androscoggin River in Maine. I have worked on hazardous waste problems since the late 1970s when I did my Ph.D. research on the pesticide Kepone. Included in my experience is work on most of the high profile CERCLA sites in the United States and I have testified before Congress and the New York State Assembly on hazardous wastes in river, estuary and lake sediments.
4. I have been asked in this declaration to explain principles of basic chemistry, as they relate to the above-titled litigation. The contents of this declaration are facts, not opinions. The sources for each factual statement, many of which consist of introductory-level chemistry textbooks, are attached as exhibits to this declaration and are referenced herein by author.

5. "Matter is anything that takes up space and has mass" (Enger and Smith (2002) at 69). Matter can be classified into two categories: pure substances and mixtures (Whitten et al. (2000) at 12).
6. A pure substance is a kind of matter that has a fixed composition and properties that do not vary (Whitten et al. (2000) at 12). "Each substance has its own characteristic set of properties that are different from the set of properties of any other substance" (Whitten et al. (2000) at 13). Pure substances exist in two forms: elements and compounds (Whitten et al. (2000) at 12).
7. An element is a form of matter consisting of a specific kind of atom that cannot be decomposed into simpler substances by chemical changes (Enger and Smith (2002) at 466; Whitten et al. (2000) at 12). "The smallest particle of an element that maintains its chemical identity through all chemical and physical changes is called an atom" (Whitten et al. (2000) at 48). "[T]he smallest particle of an element or compound that that can have a stable independent existence" is a molecule (Whitten et al. (2000) at 49). "In nearly all molecules, two or more atoms are bonded together in very small, discrete units (particles) that are electrically neutral. ... The oxygen with which we are all familiar is made up of two atoms of oxygen; it is a diatomic molecule, O₂. ... Some other elements exist as more complex molecules. One form of phosphorus molecules consists of four atoms, and sulfur exists as eight-atom molecules at ordinary temperatures and pressures. Molecules that contain two or more atoms are called polyatomic molecules." (Whitten et al. (2000) at 49.)
8. "A compound is a pure substance consisting of two or more different elements in a fixed ratio" (Whitten et al. (2000) at 15). Compounds "can be decomposed by chemical means into simpler substances" (Whitten et al. (2000) at 14) (*i.e.* elements or other compounds), but cannot be broken down or purified by physical means (Whitten et al. (2000) at 13). "The physical and chemical properties of a compound are different from the properties of its constituent elements" (Whitten et al. (2000) at 15). For example, "[s]odium chloride is a white solid that we ordinarily use as table salt. This compound is formed by the combination of the element sodium (a soft, silvery white metal that reacts violently with water) and the element chlorine (a pale green, corrosive, poisonous gas)." (Whitten et al. (2000) at 15.)
9. A mixture is a "combination[] of two or more pure substances in which each substance retains its own composition and properties" (Whitten et al. (2000) at 10). "Mixtures can be separated by physical means because each component retains its properties. For example, a mixture of salt and water can be separated by evaporating the water and leaving the solid salt behind." (Whitten et al. (2000) at 12.)
10. Phosphorus is element 15 in the periodic chart and designated by the symbol, P (Whitten et al. (2000) at 126). Phosphorus is a nonmetal and readily forms bonds with metals and nonmetals (Whitten et al. (2000) at 957). The element phosphorus is not stable at room temperature and atmospheric pressure as a single atom. Instead, phosphorus exists only as diatomic or polyatomic molecules of more than one P atom (P₂, P₄, P₈, etc.), and is referred to as "elemental phosphorus" (Zuckerman and Hagen (1988) at 18; Whitten et al.

(2000) at 49). In this respect, phosphorus is similar to oxygen and nitrogen, which only exist in nature as diatomic or polyatomic molecules in their elemental state (Whitten et al. (2000) at 49).

11. Elemental phosphorus exists (either in nature or by synthetic production) in “four or more solid allotropic¹ forms: white (or yellow),² red, and black (or violet)” (CRC Handbook (1985) at B-28). The difference between each of these forms stems from their distinct number of phosphorus atoms and molecular structure (Zuckerman and Hagen (1988) at 18). For example, white phosphorus is a polyatomic molecule (P₄) and “is the least stable and most reactive of the phosphorus allotropes” (Zuckerman and Hagen (1988) at 18).
12. The element phosphorus “is always combined in nature,” as a phosphorus compound or elemental phosphorus (Whitten et al. (2000) at 964). “Phosphorus is present in all living organisms” (Whitten et al. (2000) at 964), as well as thousands of human food products including butter, cheese, eggs and milk (USDA National Nutrient Database at Release 21). A wide variety of phosphorus compounds, such as orthophosphates and polyphosphates, are also commonly “encountered in environmental engineering practice” (Sawyer et al. (1994) at 598). “The largest use of phosphorus is in fertilizers. Phosphorus is an essential nutrient, and nature’s phosphorus cycle is very slow owing to the low solubility of most natural phosphates. Phosphate fertilizers are therefore essential.” (Whitten et al. (2000) at 965.)
13. Orthophosphates consist of a phosphorus atom bonded to four oxygen atoms (PO₄) (Chapra (1997) at 523). The release of the phosphorus atom from the bonded oxygen atoms would require chemical means (Whitten et al. (2000) at 13).
14. The following chart identifies compounds listed in 40 C.F.R. § 302.4 that include phosphorus as a constituent element.

Hazardous Substance	CASRN	Originating Authority ³
Aluminum phosphide	20859-73-8	42 U.S.C. § 6921 (RCRA)
Coumaphos	56-72-4	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
Cyclophosphamide	50-18-0	42 U.S.C. § 6921 (RCRA)
Dichlorvos	62-73-7	42 U.S.C. § 7412(b)(1) (Clean Air Act) 33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
O,O-Diethyl S-methyl dithiophosphate	3288-58-2	42 U.S.C. § 6921 (RCRA)
Diethyl-p-nitrophenyl phosphate	311-45-5	42 U.S.C. § 6921 (RCRA)

¹ Allotropes are different forms of the same element in the same physical state (Whitten et al. (2000) at 51).

² White phosphorus has two modifications (CRC Handbook (1984) at B-28).

³ The originating authority for each substance is coded on Table 302.4 under “Statutory Code.” Each originating authority is defined and designated a number between 1 and 4, as explained in the note under 40 C.F.R. § 302.4(b).

Hazardous Substance	CASRN	Originating Authority ³
O,O Diethyl O-pyrazinyl phosphorothioate	297-97-2	42 U.S.C. § 6921 (RCRA)
Diisopropylfluorophosphate (DFP)	55-91-4	42 U.S.C. § 6921 (RCRA)
Diphosphoramidate, octamethyl-	152-16-9	42 U.S.C. § 6921 (RCRA)
Diphosphoric acid, tetraethyl ester	107-49-3	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act) 42 U.S.C. § 6921 (RCRA)
Ethion	563-12-2	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
Guthion	86-50-0	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
Hexaethyl tetraphosphate	757-58-4	42 U.S.C. § 6921 (RCRA)
Hexamethylphosphoramidate	680-31-9	42 U.S.C. § 7412(b)(1) (Clean Air Act)
Hydrogen phosphide	7803-51-2	42 U.S.C. § 7412(b)(1) (Clean Air Act) 42 U.S.C. § 6921 (RCRA)
Lead phosphate	7446-27-7	42 U.S.C. § 6921 (RCRA)
Malathion	121-75-5	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
Mevinphos	7786-34-7	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
Octamethylpyrophosphoramidate	152-16-9	42 U.S.C. § 6921 (RCRA)
2H-1,3,2-Oxazaphosphorin-2-amine, N,N-bis (2-chloroethyl) tetrahydro-, 2-oxide (a.k.a. Cyclophosphamide)	50-18-0	42 U.S.C. § 6921 (RCRA)
Phosphine	7803-51-2	42 U.S.C. § 7412(b)(1) (Clean Air Act) 42 U.S.C. § 6921 (RCRA)
Phosphoric acid	7664-38-2	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
Phosphoric acid, diethyl 4-nitrophenyl ester	311-45-5	42 U.S.C. § 6921 (RCRA)
Phosphoric acid, lead(2+) salt (2:3)	7446-27-7	42 U.S.C. § 6921 (RCRA)
Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)ethyl] ester	298-04-4	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act) 42 U.S.C. § 6921 (RCRA)
Phosphorodithioic acid, O,O-diethyl S-[(ethylthio)methyl] ester	298-02-2	42 U.S.C. § 6921 (RCRA)
Phosphorodithioic acid, O,O-diethyl S-methyl ester	3288-58-2	42 U.S.C. § 6921 (RCRA)
Phosphorodithioic acid, O,O-dimethyl S-[2(methylamino)-2-oxoethyl] ester	60-51-5	42 U.S.C. § 6921 (RCRA)
Phosphorofluoridic acid, bis(1-methylethyl) ester	55-91-4	42 U.S.C. § 6921 (RCRA)
Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester	56-38-2	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act) 42 U.S.C. § 6921 (RCRA)
Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester	297-97-2	42 U.S.C. § 6921 (RCRA)
Phosphorothioic acid, O-[4-[(dimethylamino) sulfonyl] phenyl] O,O-dimethyl ester	52-85-7	42 U.S.C. § 6921 (RCRA)

Hazardous Substance	CASRN	Originating Authority³
Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl) ester	298-00-0	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act) 42 U.S.C. § 6921 (RCRA)
Phosphorus	7723-14-0	42 U.S.C. § 7412(b)(1) (Clean Air Act) 33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
Phosphorus oxychloride	10025-87-3	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
Phosphorus pentasulfide	1314-80-3	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act) 42 U.S.C. § 6921 (RCRA)
Phosphorus sulfide	1314-80-3	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act) 42 U.S.C. § 6921 (RCRA)
Phosphorus trichloride	7719-12-2	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
1-Propanol, 2,3-dibromo-, phosphate (3:1)	126-72-7	42 U.S.C. § 6921 (RCRA)
Sodium phosphate, dibasic	7558-79-4 10039-32-4 10140-65-5	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
Sodium phosphate, tribasic	7601-54-0 7558-29-4 7785-84-4 10101-89-0 10124-56-8 10361-89-4	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act)
Sulfur phosphide	1314-80-3	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act) 42 U.S.C. § 6921 (RCRA)
Tetraethyl pyrophosphate	107-49-3	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act) 42 U.S.C. § 6921 (RCRA)
Tetraethyldithiopyrophosphate	3689-24-5	42 U.S.C. § 6921 (RCRA)
Tetraphosphoric acid, hexaethyl ester	757-58-4	42 U.S.C. § 6921 (RCRA)
Thiodiphosphoric acid, tetraethyl ester	3689-24-5	42 U.S.C. § 6921 (RCRA)
Tris(2,3-dibromopropyl) phosphate	126-72-7	42 U.S.C. § 6921 (RCRA)
Zinc phosphide Zn ₃ P ₂	1314-84-7	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act) 42 U.S.C. § 6921 (RCRA)

15. The following chart identifies entries in 40 C.F.R. § 302.4 that list multiple substances or compounds.

Hazardous Substance	CASRN	Originating Authority⁴
ANTIMONY AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act) ⁵

⁴ The originating authority for each substance is coded on Table 302.4 under “Statutory Code.” Each originating authority is defined and designated a number between 1 and 4, as explained in the note under 40 C.F.R. § 302.4(b).

Hazardous Substance	CASRN	Originating Authority⁴
Antimony Compounds	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
ARSENIC AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Arsenic Compounds (inorganic including arsine)	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
BERYLLIUM AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Beryllium Compounds	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
CADMIUM AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Cadmium Compounds	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
CHLORDANE (TECHNICAL MIXTURE AND METABOLITES)	57-74-9	33 U.S.C. § 1317(a) (Clean Water Act)
CHLORINATED BENZENES	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
CHLORINATED ETHANES	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
CHLORINATED NAPHTHALENE	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
CHLORINATED PHENOLS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
CHROMIUM AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Chromium Compounds	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Cobalt Compounds	N.A.	42 U.S.C. § 7412(b)(1) (Clean Air Act)
Coke Oven Emissions	N.A.	42 U.S.C. § 7412(b)(1) (Clean Air Act)
COPPER AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
Copper Compounds	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
CYANIDES	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Cyanides (soluble salts and complexes) not otherwise specified	N.A.	42 U.S.C. § 6921 (RCRA)
DDT AND METABOLITES	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
ENDOSULFAN AND METABOLITES	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
ENDRIN AND METABOLITES	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
Glycol Ethers	N.A.	42 U.S.C. § 7412(b)(1) (Clean Air Act)
HALOETHERS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
HALOMETHANES	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)

⁵ The Clean Air Act listing of hazardous substances includes the following note at 42 U.S.C. § 7412(b)(1): “For all listings above which contain the word ‘compounds’ and for glycol ethers, the following applies: Unless otherwise specified, these listings are defined as including any unique chemical substances that contains the named chemical (i.e., antimony, arsenic, etc.) as part of that chemical’s infrastructure.”

Hazardous Substance	CASRN	Originating Authority⁴
HEPTACHLOR AND METABOLITES	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
HEXACHLOROCYCLOHEXANE (all isomers)	608-73-1	33 U.S.C. § 1317(a) (Clean Water Act)
LEAD AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Lead Compounds	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Manganese Compounds	N.A.	42 U.S.C. § 7412(b)(1) (Clean Air Act)
MERCURY AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Mercury Compounds	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Fine Mineral Fibers	N.A.	42 U.S.C. § 7412(b)(1) (Clean Air Act)
NICKEL AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Nickel Compounds	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
NITROPHENOLS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
NITROSAMINES	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
PHTHALATE ESTERS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
POLYCHLORINATED BIPHENYLS	1336-36-3	33 U.S.C. § 1321(b)(2)(A) (Clean Water Act) 33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Polycyclic Organic Matter	N.A.	42 U.S.C. § 7412(b)(1) (Clean Air Act)
POLYNUCLEAR AROMATIC HYDROCARBONS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
Radionuclides (Include Radon)	N.A.	42 U.S.C. § 7412(b)(1) (Clean Air Act)
SELENIUM AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
Selenium Compounds	N.A.	33 U.S.C. § 1317(a) (Clean Water Act) 42 U.S.C. § 7412(b)(1) (Clean Air Act)
SILVER AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
THALLIUM AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)
Unlisted Hazardous Wastes Characteristic of Corrosivity	N.A.	42 U.S.C. § 9621 (RCRA)
Unlisted Hazardous Wastes Characteristic of Ignitability	N.A.	42 U.S.C. § 9621 (RCRA)
Unlisted Hazardous Wastes Characteristic of Reactivity	N.A.	42 U.S.C. § 9621 (RCRA)
Unlisted Hazardous Wastes Characteristic of Toxicity	N.A.	42 U.S.C. § 9621 (RCRA)
ZINC AND COMPOUNDS	N.A.	33 U.S.C. § 1317(a) (Clean Water Act)

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on 3/23, 2009

A handwritten signature in black ink, appearing to be "M. F. C. M.", is written over a horizontal line.

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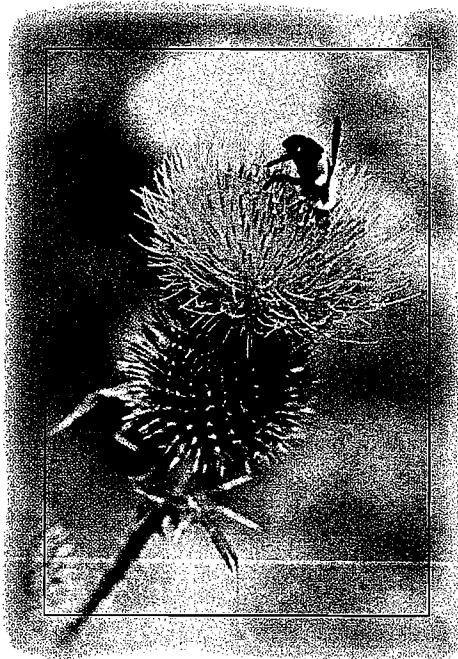
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- Ex. 3. Zuckerman, J.J. and A.P. Hagen, Inorganic Reactions and Methods, Vol. 7, VCH Publishers, Inc. (1988).
- Ex. 4. CRC Handbook of Chemistry and Physics: A Ready-Reference Book of Chemical and Physical Data, Editor-in-Chief Robert C. Weast, CRC Press, Inc. (65th ed. 1985).
- Ex. 5. Sawyer, Clair N., Perry L. McCarty and Gene F. Parkin, Chemistry for Environmental Engineering, McGraw Hill, Inc. (4th ed. 1994).
- Ex. 6. Chapra, Steven C., Surface Water-Quality Modeling, McGraw Hill, Inc. (1997).
- Ex. 7. U.S. Department of Agriculture, National Nutrient Database for Standard Reference, Release 21 (2008).

Exhibit 1

eighth edition

Environmental Science

A Study of Interrelationships



Eldon D. Enger
Delta College

Bradley F. Smith
Western Washington University



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but it cannot be proved true in *every* case because it is impossible to test *every* case. It is important to recognize that the word *theory* is often used in a much less restrictive sense. Often it is used incorrectly to describe a vague idea or a hunch. This is not a theory in the scientific sense. So when you see or hear the word *theory* you must look at the context to see if the speaker or writer is referring to a theory in the scientific sense.

Now that we have some idea of how the scientific method works, let's look at an example. In many rivers in industrial parts of the world, it is possible to notice tumors of the skin and liver in the fish that live in the rivers (*observation*). This raises the question of what causes the tumors. Many people feel that the tumors are caused by the toxic chemicals that have been released into the rivers by industrial plants (*hypothesis*). Now, how could an experiment be conducted to test the hypothesis? If an industrial plant is suspected of releasing toxic chemicals that cause tumors, resident species of fish that do not migrate can be collected upstream and downstream from the plant's wastewater discharge pipes (outfall). Fish collected above the outfall constitute the control group, and those collected below the outfall constitute the experimental group. Large numbers of fish would have to be collected and examined. If the fish below the outfall have significantly more tumors than those above the outfall, it is because of where they live in the river and so the toxic chemicals from the industrial plants are a probable cause of the tumors. This is particularly true if the chemicals are already known to cause tumors. After the data were evaluated, the results of the experiment would be published. Certainly, the owners of the industrial plants would want to look at the data and might want to repeat the experiment to see if they get the same results.

programs should be instituted, or evaluate the significance of a beautiful landscape. These tasks are beyond the scope of scientific investigation. This does not mean that scientists cannot comment on such issues. They often do. But they should not be regarded as more knowledgeable on these issues just because they are scientists. Scientists may know more about the scientific aspects of these issues, but they struggle with the same moral and ethical questions that face all people, and their judgments on these matters can be just as faulty as anyone else's.

It is important to differentiate between the scientific data collected and the opinions scientists have about what the data mean. Scientists form and state opinions that may not always be supported by fact, just as other people do. Equally reputable scientists commonly state opinions that are in direct contradiction. This is especially true in environmental science, where predictions about the future must be based on inadequate or fragmentary data. The issue of climate change (covered in chapter 18) is an example of this.

It is important to recognize that some scientific knowledge can be used to support both valid and invalid conclusions. For example, the following statements are all factual.

1. Many of the kinds of chemicals used in modern agriculture are toxic to humans and other animals.
2. Agricultural chemicals have been detected in small amounts in some agricultural products.
3. Low levels of some toxic materials have been strongly linked to a variety of human illnesses.

This does not mean that all foods grown with the use of chemicals are less nutritious or are dangerous to health or that "organically grown" foods are necessarily more nutritious or more healthful because they have been grown without agricultural chemicals. The idea that something that is artificial is necessarily bad and something natural is necessarily good is an oversimplification. After all, many plants such as tobacco, poison ivy,

and rhubarb leaves naturally contain toxic materials, while the use of chemical fertilizers has contributed to the health of major portions of the world since their use accounts for about one-third of the food grown in the world. However, it is appropriate to question if the use of agricultural chemicals is always necessary or if trace amounts of specific agricultural chemicals in food are dangerous. It is often easy to jump to conclusions or confuse fact with hypothesis, particularly when we generalize.

The Structure of Matter

Now that we have an appreciation for the methods of science, it is time to explore some basic information and theories about the structure and function of various kinds of matter. **Matter** is anything that takes up space and has mass. Air, water, trees, cement, and gold are all examples of matter. A central theory that describes the structure and activity of matter is the **kinetic molecular theory**. This theory states that all matter is made up of tiny objects that are in constant motion. Although different kinds of matter have different properties, they are similar in one fundamental way. They are all made up of one or more kinds of smaller subunits called atoms.

Atomic Structure

Atoms are the fundamental subunits of matter. They in turn are made up of protons, neutrons, and electrons. There are 92 kinds of atoms found in nature. Each kind forms a specific type of matter known as an **element**. Gold (Au), oxygen (O), and mercury (Hg) are examples of elements. All atoms are composed of a central region known as a **nucleus**, which is composed of two kinds of relatively heavy particles: positively charged particles called **protons** and uncharged particles called **neutrons**. Surrounding the nucleus are clouds of relatively lightweight, fast-moving, negatively charged particles called **electrons**. As mentioned earlier, each kind of element is

to p 5

Applications of Science

Science is a powerful tool for developing an understanding of the natural world, but it cannot analyze international politics, decide if family-planning

supported in an area over an extended period of time.

catalyst A substance that alters the rate of a reaction but is not itself changed.

chemical bond The physical attraction between atoms that results from the interaction of their electrons.

chemical weathering Processes that involve the chemical alteration of rock in such a manner that it is more likely to fragment or to be dissolved.

chlorinated hydrocarbon A class of pesticide consisting of carbon, hydrogen, and chlorine, which are very stable.

chlorofluorocarbons (CFC) Stable compounds containing carbon, hydrogen, chlorine and fluorine. They were formerly used as refrigerants, propellants in aerosol containers, and expanders in foam products. They are linked to the depletion of the ozone layer.

chronic toxicity A serious effect, such as an illness or death, that occurs after prolonged exposure to small doses of a toxic substance.

clear-cutting A forest harvesting method in which all the trees in a large area are cut and removed.

climax community Last stage of succession; a relatively stable, long-lasting, complex, and interrelated community of plants, animals, fungi, and bacteria.

coevolution Two or more species of organisms reciprocally influencing the evolutionary direction of the other.

combustion The process of releasing chemical bond energy from fuel.

commensalism The relationship between organisms in which one organism benefits while the other is not affected.

community Interacting groups of different species.

competition An interaction between two organisms in which both require the same limited resource, which results in harm to both.

composting A waste disposal system whereby organic matter is allowed to decay to a usable product.

compound A kind of matter composed of two or more different kinds of atoms bonded together.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) The 1980 U.S. law that addressed the issue of cleanup of hazardous-waste sites.

confined aquifer An aquifer that is bounded on the top and bottom by impermeable confining layers.

conservation To use in the best possible way so that the greatest long-term benefit is realized by society.

conservation ethic An environmental ethic that stresses a balance between total development and absolute preservation.

consumers Organisms that use other organisms as food.

contour farming A method of tilling and planting at right angles to the slope, which reduces soil erosion by runoff.

controlled experiment An experiment in which two groups are compared. One, the control, is used as a basis of comparison and the other, the experimental, has one factor different from the control.

coral reef ecosystem A tropical, shallow-water, marine ecosystem dominated by coral organisms that produce external skeletons.

corporation A business structure that has a particular legal status.

corrosiveness Ability of a chemical to degrade standard materials.

cost-benefit analysis A method used to determine the feasibility of pursuing a particular project by balancing estimated costs against expected benefits.

cover A term used to refer to any set of physical features that conceals or protects animals from the elements or their enemies.

crust The thin, outer, solid surface of the Earth.

death phase The portion of the population growth curve of some organisms that shows the population declining.

death rate The number of deaths per thousand individuals in the population per year.

decommissioning Decontaminating and disassembling a nuclear power plant and safely disposing of the radioactive materials.

decomposers Small organisms, like bacteria and fungi, that cause the decay of dead organic matter and recycle nutrients.

demand Amount of a product that consumers are willing and able to buy at various prices.

demographic transition The hypothesis that economies proceed through a series of stages, beginning with growing populations high birth and death rates and low economic development and ending with stable populations with low birth and death rates and high economic development.

demography The study of human populations, their characteristics, and their changes.

denitrifying bacteria Bacteria that convert nitrogen compounds into nitrogen gas.

density-dependent limiting factors Those limiting factors that become more severe as the size of the population increases.

density-independent limiting factors Those limiting factors that are not affected by population size.

desert A biome that receives less than 25 centimeters (10 inches) of precipitation per year.

desertification The conversion of arid and semiarid lands into deserts by inappropriate farming practices or overgrazing.

detritus Tiny particles of organic material that result from fecal waste material or the decomposition of plants and animals.

development ethic Philosophy that states that the human race should be the master of nature and that the Earth and its resources exist for human benefit and pleasure.

dispersal Migration of organisms from a concentrated population into areas with lower population densities.

domestic water Water used for domestic activities, such as drinking, air conditioning, bathing, washing clothes, washing dishes, flushing toilets, and watering lawns and gardens.

ecocentrism An approach to environmental responsibility that maintains that the environment deserves direct moral consideration rather than consideration derived merely from human interests.

ecology A branch of science that deals with the interrelationship between organisms and their environment.

economic costs Those monetary costs that are necessary to exploit a natural resource.

economic growth The perceived increase in monetary growth within a society.

ecosystem A group of interacting species along with their physical environment.

ectoparasite A parasite that is adapted to live on the outside of its host.

electron The lightweight, negatively charged particle that moves around at some distance from the nucleus of an atom.

element A form of matter consisting of a specific kind of atom.

emergent plants Aquatic vegetation that is rooted on the bottom but has leaves that float on the surface or protrude above the water.

emigration Movement out of an area that was once one's place of residence.

endangered species Those species that are present in such small numbers that they are in immediate jeopardy of becoming extinct.

Exhibit 2

GENERAL CHEMISTRY

SIXTH EDITION

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University of Georgia, Athens

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over legend: The oil obtained from sunflower seeds contains triesters of oleic acid,
 $\text{I}_3(\text{CH}_2)_7=\text{CH}(\text{CH}_2)_7\text{COOH}$, and linoleic acid,
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The shapes of these unsaturated molecules allow the ester to remain an oil instead of solidifying
as a fat.
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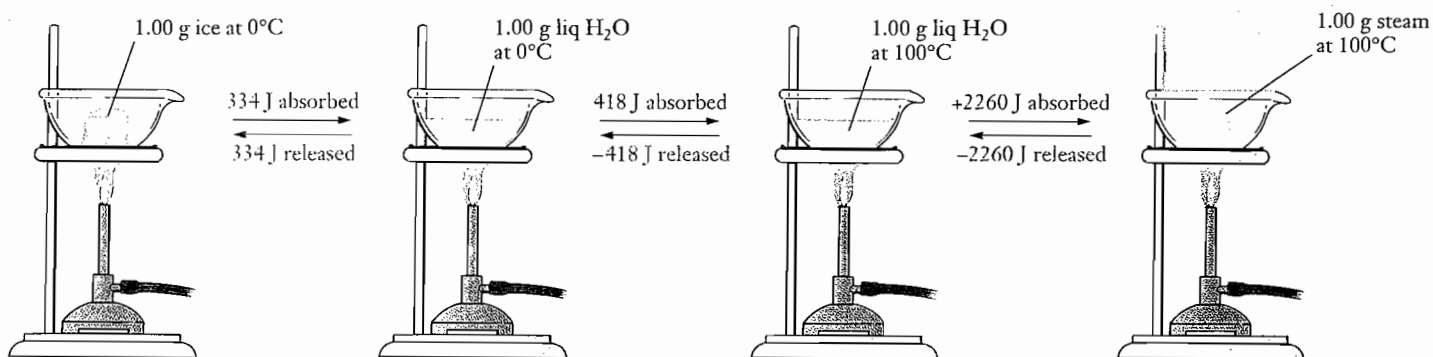


Figure 1-5 Changes in energy that accompany some physical changes for water. The energy unit joules (J) is defined in Section 1-13.

water to form ice. The changes in energy that accompany these physical changes for water are shown in Figure 1-5. At a pressure of one atmosphere, ice always melts at the same temperature (0°C), and pure water always boils at the same temperature (100°C).

1-5 MIXTURES, SUBSTANCES, COMPOUNDS, AND ELEMENTS

By “composition of a mixture,” we mean both the identities of the substances present and their relative amounts in the mixture.

The blue copper(II) sulfate solution in Figure 1-4c is a homogeneous mixture.



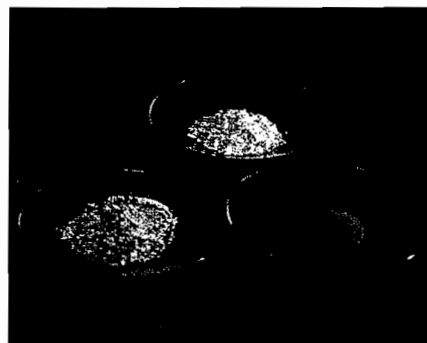
Mixtures are combinations of two or more pure substances in which each substance retains its own composition and properties. Almost every sample of matter that we ordinarily encounter is a mixture. The most easily recognized type of mixture is one in which different portions of the sample have recognizably different properties. Such a mixture, which is not uniform throughout, is called **heterogeneous**. Examples include mixtures of salt and charcoal (in which two components with different colors can be distinguished readily from each other by sight), foggy air (which includes a suspended mist of water droplets), and vegetable soup. Another kind of mixture has uniform properties throughout; such a mixture is described as a **homogeneous mixture** and is also called a **solution**. Examples include salt water; some *alloys*, which are homogeneous mixtures of metals in the solid state; and air (free of particulate matter or mists). Air is a mixture of gases. It is mainly nitrogen, oxygen, argon, carbon dioxide, and water vapor. There are only trace amounts of other substances in the atmosphere.

An important characteristic of all mixtures is that they can have variable composition. (For instance, we can make an infinite number of different mixtures of salt and sugar by varying the relative amounts of the two components used.) Consequently, repeating the same experiment on mixtures from different sources may give different results, whereas the same treatment of a pure sample will always give the same results. When the distinction between homogeneous mixtures and pure substances was realized and methods were developed (in the late 1700s) for separating mixtures and studying pure substances, consistent results could be obtained. This resulted in reproducible chemical properties, which formed the basis of real progress in the development of chemical theory.

A heterogeneous mixture of two minerals: galena (black) and quartz (white).



See the *Saunders Interactive General Chemistry CD-ROM*, Screen 1.13, Mixtures and Pure Substances.



(a)



(b)

Figure 1-6 (a) A mixture of iron and sulfur is a *heterogeneous* mixture. (b) Like any mixture it can be separated by physical means, such as removing the iron with a magnet.



See the *Saunders Interactive General Chemistry CD-ROM*, Screen 1.14, Separation of Mixtures.

Mixtures can be separated by physical means because each component retains its properties (Figures 1-6 and 1-7). For example, a mixture of salt and water can be separated by evaporating the water and leaving the solid salt behind. To separate a mixture of sand and salt, we could treat it with water to dissolve the salt, collect the sand by filtration, and then evaporate the water to reclaim the solid salt. Very fine iron powder can be mixed with powdered sulfur to give what appears to the naked eye to be a homogeneous mixture of the two. Separation of the components of this mixture is easy, however. The iron may be removed by a magnet, or the sulfur may be dissolved in carbon disulfide, which does not dissolve iron (Figure 1-6).

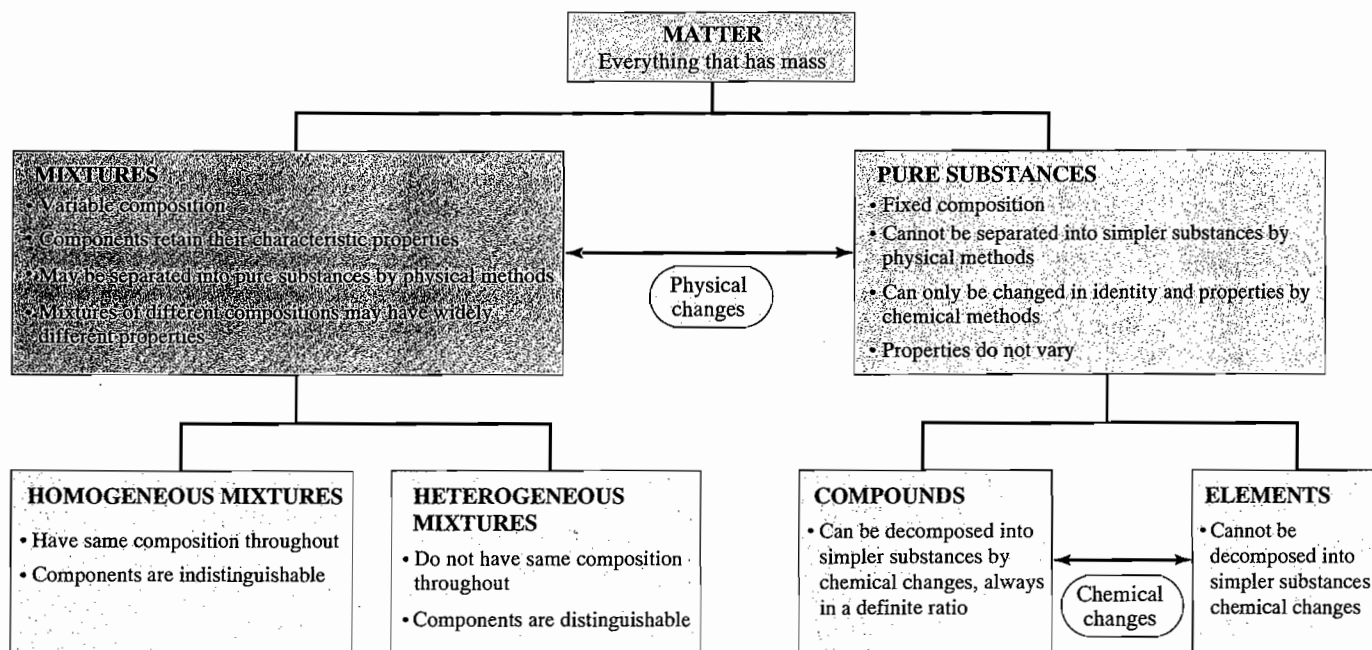


Figure 1-7 One scheme for classification of matter. Arrows indicate the general means by which matter can be separated.

In *any* mixture, (1) the composition can be varied and (2) each component of the mixture retains its own properties. *X*

Imagine that we have a sample of muddy river water (a heterogeneous mixture). We might first separate the suspended dirt from the liquid by filtration. Then we could remove dissolved air by warming the water. Dissolved solids might be removed by cooling the sample until some of it freezes, pouring off the liquid, and then melting the ice. Other dissolved components might be separated by distillation or other methods. Eventually we would obtain a sample of pure water that could not be further separated by any physical separation methods. No matter what the original source of the impure water—the ocean, the Mississippi River, a can of tomato juice, and so on—water samples obtained by purification all have identical composition, and, under identical conditions, they all have identical properties. Any such sample is called a substance, or sometimes a pure substance.

The first ice that forms is quite pure. The dissolved solids tend to stay behind in the remaining liquid.

A **substance** cannot be further broken down or purified by physical means. A substance is matter of a particular kind. Each substance has its own characteristic properties that are different from the set of properties of any other substance.

If we use the definition of *substance*, the phrase *pure substance* appear to be redundant.

Now suppose we decompose some water by passing electricity through it (Figure 1-8). (An *electrolysis* process is a chemical reaction.) We find that the water is converted into two simpler substances, hydrogen and oxygen; more significantly, hydrogen and

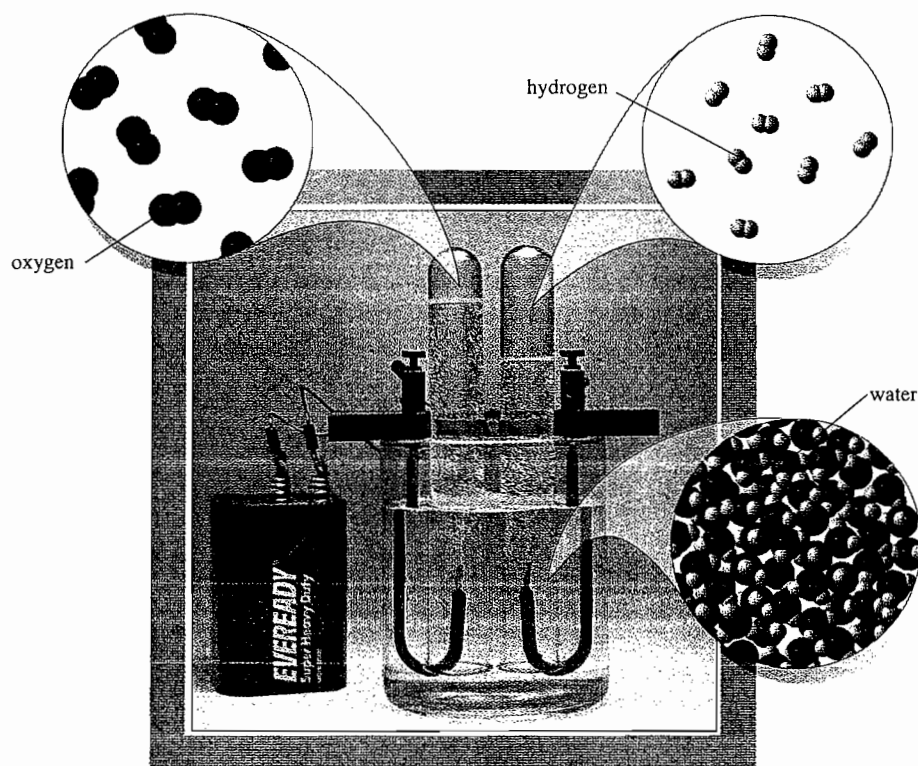


Figure 1-8 Electrolysis apparatus for small-scale chemical decomposition of water by electrical energy. The volume of hydrogen produced (*right*) is twice that of oxygen (*left*). Some dilute sulfuric acid is added to increase the conductivity.

oxygen are *always* present in the same ratio by mass, 11.1% to 88.9%. These observations allow us to identify water as a compound.

A **compound** is a substance that can be decomposed by chemical means into simpler substances, always in the same ratio by mass.

As we continue this process, starting with any substance, we eventually reach a stage at which the new substances formed cannot be further broken down by chemical means. The substances at the end of this chain are called elements.

An **element** is a substance that cannot be decomposed into simpler substances by chemical changes.

For instance, neither of the two gases obtained by the electrolysis of water—hydrogen and oxygen—can be further decomposed, so we know that they are elements.

As another illustration (Figure 1-9), pure calcium carbonate (a white solid present in limestone and seashells) can be broken down by heating to give another white solid (call it A) and a gas (call it B) in the mass ratio 56.0:44.0. This observation tells us that calcium carbonate is a compound. The white solid A obtained from calcium carbonate can be further broken down into a solid and a gas in a definite ratio by mass, 71.5:28.5. But neither of these can be further decomposed, so they must be elements. The gas is identical to the oxygen obtained from the electrolysis of water; the solid is a metallic element called calcium. Similarly, the gas B, originally obtained from calcium carbonate, can be decomposed into two elements, carbon and oxygen, in a fixed mass ratio, 27.3:72.7. This sequence illustrates that a compound can be broken apart into simpler substances at a fixed mass ratio; those simpler substances may be either elements or simpler compounds.

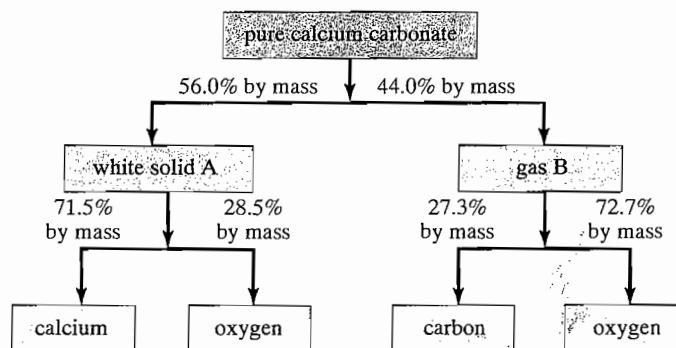


Figure 1-9 Diagram of the decomposition of calcium carbonate to give a white solid A (56.0% by mass) and a gas B (44.0% by mass). This decomposition into simpler substances at a fixed ratio proves that calcium carbonate is a compound. The white solid A further decomposes to give the elements calcium (71.5% by mass) and oxygen (28.5% by mass). This proves that the white solid A is a compound; it is known as calcium oxide. The gas B also can be broken down to give the elements carbon (27.3% by mass) and oxygen (72.7% by mass). This establishes that gas B is a compound; it is known as carbon dioxide.

Furthermore, we may say that a compound is a pure substance consisting of two or more different elements in a fixed ratio. Water is 11.1% hydrogen and 88.9% oxygen by mass. Similarly, carbon dioxide is 27.3% carbon and 72.7% oxygen by mass, and calcium oxide (the white solid A in the previous discussion) is 71.5% calcium and 28.5% oxygen by mass. We could also combine the numbers in the previous paragraph to show that calcium carbonate is 40.1% calcium, 12.0% carbon, and 47.9% oxygen by mass. Observations such as these on innumerable pure compounds led to the statement of the **Law of Definite Proportions** (also known as the **Law of Constant Composition**):

Different samples of any pure compound contain the same elements in the same proportions by mass.

The physical and chemical properties of a compound are different from the properties of its constituent elements. Sodium chloride is a white solid that we ordinarily use as table salt (Figure 1-10). This compound is formed by the combination of the element sodium (a soft, silvery white metal that reacts violently with water; see Figure 1-4d) and the element chlorine (a pale green, corrosive, poisonous gas; see Figure 1-2c).

Recall that elements are substances that cannot be decomposed into simpler substances by chemical changes. Nitrogen, silver, aluminum, copper, gold, and sulfur are other examples of elements.

We use a set of **symbols** to represent the elements. These symbols can be written more quickly than names, and they occupy less space. The symbols for the first 109 elements consist of either a capital letter *or* a capital letter and a lowercase letter, such as C (carbon) or Ca (calcium). A list of the known elements and their symbols is given inside the front cover.

In the past, the discoverers of elements claimed the right to name them (see the essay "The Names of the Elements" on page 68), although the question of who had actually discovered the elements first was sometimes disputed. In modern times, new elements are given temporary names and three-letter symbols based on a numerical system. These designations are used until the question of the right to name the newly discovered elements is resolved. Decisions resolving the names of elements 104 through 109 were announced in 1997 by the International Union of Pure and Applied Chemistry (IUPAC), an international organization that represents chemical societies from 40 countries. IUPAC makes recommendations regarding many matters of convention and terminology in chemistry. These recommendations carry no legal force, but they are normally viewed as authoritative throughout the world.

A short list of symbols of common elements is given in Table 1-2. Learning this list will be helpful. Many symbols consist of the first one or two letters of the element's English name. Some are derived from the element's Latin name (indicated in parentheses in Table 1-2) and one, W for tungsten, is from the German *Wolfram*. Names and symbols for additional elements should be learned as they are encountered.

Most of the earth's crust is made up of a relatively small number of elements. Only 10 of the 88 naturally occurring elements make up more than 99% by mass of the earth's crust, oceans, and atmosphere (Table 1-3). Oxygen accounts for roughly half. Relatively few elements, approximately one fourth of the naturally occurring ones, occur in nature as free elements. The rest are always found chemically combined with other elements.

A very small amount of the matter in the earth's crust, oceans, and atmosphere is involved in living matter. The main element in living matter is carbon, but only a tiny

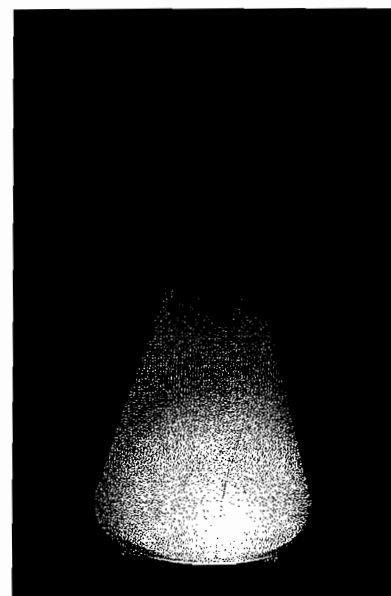


Figure 1-10 The reaction of sodium, a solid element, and chlorine, a gaseous element, to produce sodium chloride (table salt). This reaction gives off considerable energy in the form of heat and light.

The other known elements have been made artificially in laboratories, as described in Chapter 26.

2-1 ATOMS AND MOLECULES

The term “atom” comes from the Greek language and means “not divided” or “indivisible.”

The Greek philosopher Democritus (470–400 BC) suggested that all matter is composed of tiny, discrete, indivisible particles that he called atoms. His ideas, based entirely on philosophical speculation rather than experimental evidence, were rejected for 2000 years. By the late 1700s, scientists began to realize that the concept of atoms provided an explanation for many experimental observations about the nature of matter.

By the early 1800s, the Law of Conservation of Matter (Section 1-1) and the Law of Definite Proportions (Section 1-5) were both accepted as general descriptions of how matter behaves. John Dalton (1766–1844), an English schoolteacher, tried to explain why matter behaves in such systematic ways as those expressed here. In 1808, he published the first “modern” ideas about the existence and nature of atoms. Dalton’s explanation summarized and expanded the nebulous concepts of early philosophers and scientists; more importantly, his ideas were based on *reproducible experimental results* of measurements by many scientists. These ideas form the core of **Dalton’s Atomic Theory**, one of the highlights in the history of scientific thought. In condensed form, Dalton’s ideas may be stated as follows:

The radius of a calcium atom is only 1.97×10^{-8} cm, and its mass is 6.66×10^{-23} g.

Statement 3 is true for *chemical* reactions. It is not true, however, for *nuclear* reactions (Chapter 26).

1. An element is composed of extremely small, indivisible particles called atoms.
2. All atoms of a given element have identical properties that differ from those of other elements.
3. Atoms cannot be created, destroyed, or transformed into atoms of another element.
4. Compounds are formed when atoms of different elements combine with one another in small whole-number ratios.
5. The relative numbers and kinds of atoms are constant in a given compound.

Dalton believed that atoms were solid, indivisible spheres, an idea we now reject. But he showed remarkable insight into the nature of matter and its interactions. Some of his ideas could not be verified (or refuted) experimentally at the time. They were based on the limited experimental observations of his day. Even with their shortcomings, Dalton’s ideas provided a framework that could be modified and expanded by later scientists. Thus John Dalton is often considered to be the father of modern atomic theory.

The smallest particle of an element that maintains its chemical identity through all chemical and physical changes is called an **atom** (Figure 2-1). In Chapter 5, we shall study the structure of the atom in detail; let us simply summarize here the main features of atomic composition. Atoms, and therefore *all* matter, consist principally of three **fundamental particles**: *electrons*, *protons*, and *neutrons*. These are the basic building blocks of



Figure 2-1 Relative sizes of monatomic molecules (single atoms) of the noble gases.

TABLE 2-1 *Fundamental Particles of Matter*

Particle (symbol)	Approximate Mass (amu)*	Charge (relative scale)
electron (e^-)	0.0	1-
proton (p or p^+)	1.0	1+
neutron (n or n^0)	1.0	none

*1 amu = 1.6605×10^{-24} g

atoms. The masses and charges of the three fundamental particles are shown in Table 2-1. The masses of protons and neutrons are nearly equal, but the mass of an electron is much smaller. Neutrons carry no charge. The charge on a proton is equal in magnitude, but opposite in sign, to the charge on an electron. Because atoms are electrically neutral,

an atom contains equal numbers of electrons and protons.

The **atomic number** (symbol is Z) of an element is defined as the number of protons in the nucleus. In the periodic table, elements are arranged in order of increasing atomic numbers. These are the red numbers above the symbols for the elements in the periodic table on the inside front cover. For example, the atomic number of silver is 47.

A **molecule** is the smallest particle of an element or compound that can have a stable independent existence. In nearly all molecules, two or more atoms are bonded together in very small, discrete units (particles) that are electrically neutral.

Individual oxygen atoms are not stable at room temperature and atmospheric pressure. Single atoms of oxygen mixed under these conditions quickly combine to form pairs. The oxygen with which we are all familiar is made up of two atoms of oxygen; it is a *diatomic* molecule, O_2 . Hydrogen, nitrogen, fluorine, chlorine, bromine, and iodine are other examples of diatomic molecules (Figure 2-2).

Some other elements exist as more complex molecules. One form of phosphorus molecules consists of four atoms, and sulfur exists as eight-atom molecules at ordinary temperatures and pressures. Molecules that contain two or more atoms are called *polyatomic* molecules (Figure 2-3).

47 ← atomic number
Ag ← symbol

For Group VIIIA elements, the gases, a molecule contains only atom, and so an atom and a molecule are the same (see Figure 2-1).

You should remember the common elements that occur as diatomic molecules: H_2 , N_2 , O_2 , F_2 , Cl_2

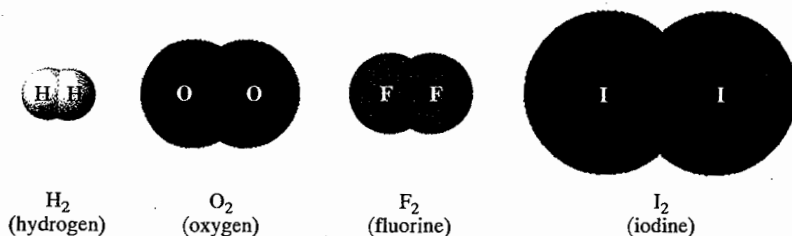


Figure 2-2 Models of diatomic molecules of some elements, approximately to scale.

TABLE 4-2 *The Periodic Table*

Alkali metals			Metals										Noble gases							
IA Alkaline earth metals			Nonmetals										VIII A							
(1)													(18)							
1	1 H	IIA (2)	Transition metals										III A (13)	IV A (14)	VA (15)	VIA (16)	VII A (17)	2 He		
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne		
3	11 Na	12 Mg	IIIB (3)	IVB (4)	VB (5)	VIB (6)	VII B (7)	VIII B (8) (9) (10)			IB (11)	IIB (12)	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar		
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr		
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe		
6	55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn		
7	87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt											
				* 58 Ce 59 Pr 60 Nd 61 Pm 62 Sm 63 Eu 64 Gd 65 Tb 66 Dy 67 Ho 68 Er 69 Tm 70 Yb 71 Lu																
				† 90 Th 91 Pa 92 U 93 Np 94 Pu 95 Am 96 Cm 97 Bk 98 Cf 99 Es 100 Fm 101 Md 102 No 103 Lr																

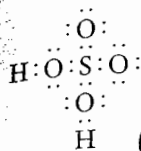
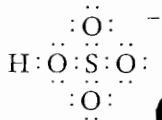
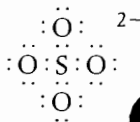
There are other systems for numbering the groups in the periodic table. We number the groups by the standard American system of A and B groups. An alternative system in which the groups are numbered 1 through 18 is shown in parentheses.

TABLE 4-3 *Some Physical Properties of Metals and Nonmetals*

Metals	Nonmetals
1. High electrical conductivity that decreases with increasing temperature	1. Poor electrical conductivity (except carbon in the form of graphite)
2. High thermal conductivity	2. Good heat insulators (except carbon in the form of diamond)
3. Metallic gray or silver luster*	3. No metallic luster
4. Almost all are solids†	4. Solids, liquids, or gases
5. Malleable (can be hammered into sheets)	5. Brittle in solid state
6. Ductile (can be drawn into wires)	6. Nonductile

*Except copper and gold.

†Except mercury; cesium and gallium melt in a protected hand.

Sulfuric acid, H_2SO_4 Hydrogen sulfate ion, HSO_4^- Sulfate ion, SO_4^{2-}

NITROGEN AND PHOSPHORUS

The Group VA elements provide a dramatic illustration of the vertical trends in metallic properties. In this family, nitrogen and phosphorus are nonmetals, arsenic is predominantly nonmetallic, antimony is more metallic, and bismuth is definitely metallic. Properties of the Group VA elements are listed in Table 24-7.

Oxidation states of the VA elements range from -3 to $+5$. Odd-numbered oxidation states are favored. The VA elements form very few monatomic ions. Ions with a charge of $3-$ occur for N and P, as in Mg_3N_2 and Ca_3P_2 .

All of the Group VA elements show the -3 oxidation state in covalent compounds such as NH_3 and PH_3 . The $+5$ oxidation state is found only in covalent compounds such as phosphorus pentafluoride, PF_5 ; nitric acid, HNO_3 ; and phosphoric acid, H_3PO_4 ; and in polyatomic ions such as NO_3^- and PO_4^{3-} . Each Group VA element exhibits the $+3$ oxidation state in one of its oxides, for instance, N_2O_3 and P_4O_6 . These are acid anhydrides of nitrous acid, HNO_2 , and phosphorous acid, H_3PO_3 ; both are weak acids. No other element exhibits more oxidation states than nitrogen (Table 24-8).

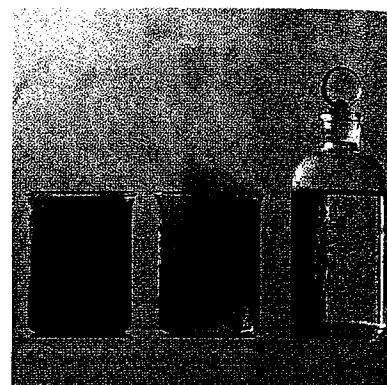
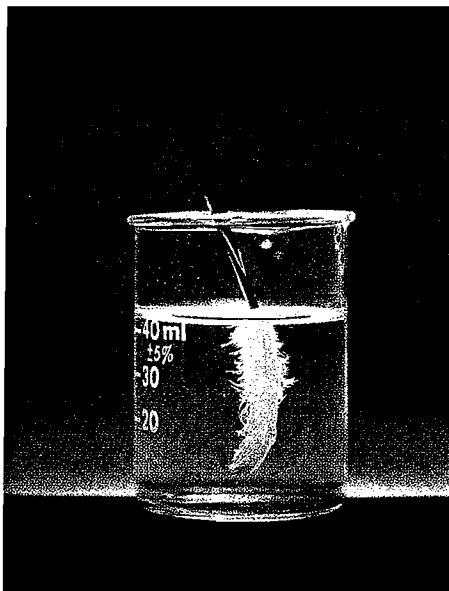
TABLE 24-7 Properties of the Group VA Elements

Property	N	P	As	Sb	Bi
Physical state (1 atm, 25°C)	gas	solid	solid	solid	solid
Color	colorless	red, white, black	yellow, gray	yellow, gray	gray
Outermost electrons	$2s^2 2p^3$	$3s^2 3p^3$	$4s^2 4p^3$	$5s^2 5p^3$	$6s^2 6p^3$
Boiling point ($^\circ\text{C}$)	-210	44 (white)	813 (gray, 28 atm)*	631 (gray)	271
Melting point ($^\circ\text{C}$)	-196	280 (white)	sublimes 613	1750	1560
Atomic radius (\AA)	0.75	1.10	1.20	1.40	1.50
Electronegativity	3.0	2.1	2.1	1.9	1.8
Ionization energy (kJ/mol)	1402	1012	947	834	703
Oxidation states	-3 to $+5$	-3 to $+5$	-3 to $+5$	-3 to $+5$	-3 to $+5$

*melts at lower pressures.



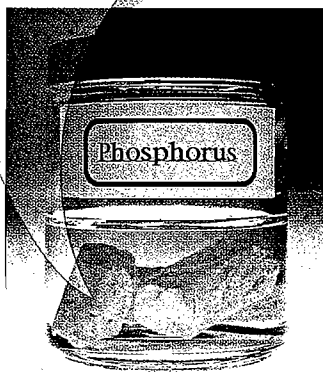
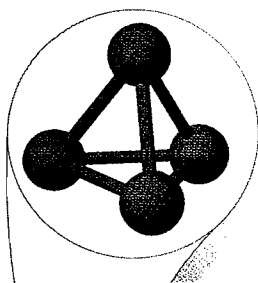
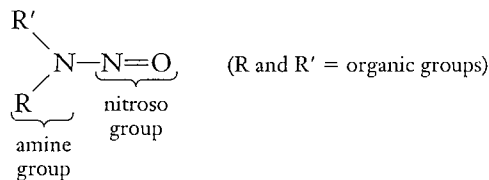
Nitric acid, HNO_3 , reacts with protein-containing materials such as this feather, staining them yellow. Perhaps you have spilled nitric acid on your skin and seen it turn yellow.



Copper (left beaker) and zinc (right beaker) react with concentrated nitric acid.

NaNO_2 and NaNO_3 as Food Additives

The brown color of “old” meat is the result of oxidation of blood and is objectionable to many consumers. Nitrites and nitrates are added to food to retard this oxidation and also to prevent growth of botulism bacteria. Nitrate ions, NO_3^- , are reduced to NO_2^- ions, which are then converted to NO . This in turn reacts with the brown oxidized form of the heme in blood. This reaction keeps meat red longer. Controversy has arisen, however, concerning the possibility that nitrites combine with amines under the acidic conditions in the stomach to produce carcinogenic *nitrosoamines*.

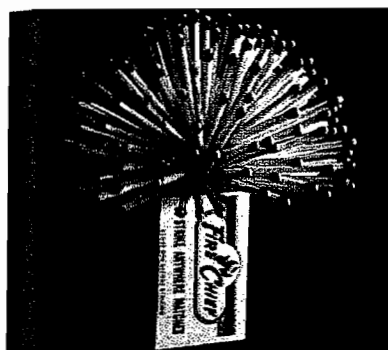


White phosphorus reacts with air, so it is stored under water. It contains tetrahedral P_4 molecules.

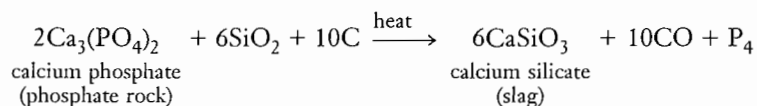
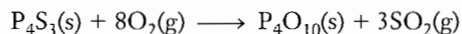
24-17 PHOSPHORUS

Phosphorus is always combined in nature. Phosphorus is present in all living organisms—as organophosphates and in calcium phosphates such as hydroxyapatite, $\text{Ca}_5(\text{PO}_4)_3(\text{OH})$, and fluorapatite, $\text{Ca}_5(\text{PO}_4)_3\text{F}$, in bones and teeth. It also occurs in these and related compounds in phosphate minerals, which are mined mostly in Florida and North Africa.

Industrially, the element is obtained from phosphate minerals by heating them at 1200 to 1500°C in an electric arc furnace with sand (SiO_2) and coke.

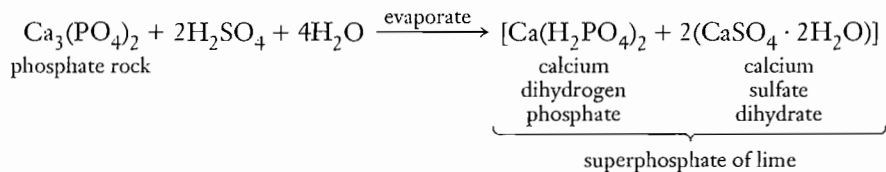


The tips of “strike anywhere” matches contain tetraphosphorus trisulfide and red phosphorus. Friction converts kinetic energy into heat, which initiates a spontaneous reaction.



Vaporized phosphorus is condensed to a white solid (mp = 44.2°C, bp = 280.3°C) under H₂O to prevent oxidation. Even when kept under H₂O, white phosphorus slowly converts to the more stable red phosphorus allotrope (mp = 597°C; sublimes at 431°C). Red phosphorus and tetraphosphorus trisulfide, P₄S₃, are used in matches. They do not burn spontaneously, yet they ignite easily when heated by friction. Both white and red phosphorus are insoluble in water.

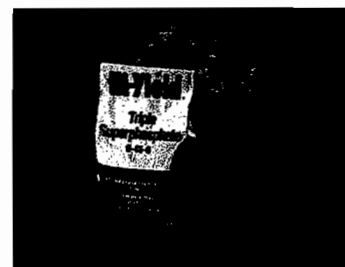
The largest use of phosphorus is in fertilizers. Phosphorus is an essential nutrient, and nature’s phosphorus cycle is very slow owing to the low solubility of most natural phosphates. Phosphate fertilizers are therefore essential. To increase the solubility of the natural phosphates, they are treated with H₂SO₄ to produce “superphosphate of lime,” a mixture of two salts. This solid is pulverized and applied as a powder.



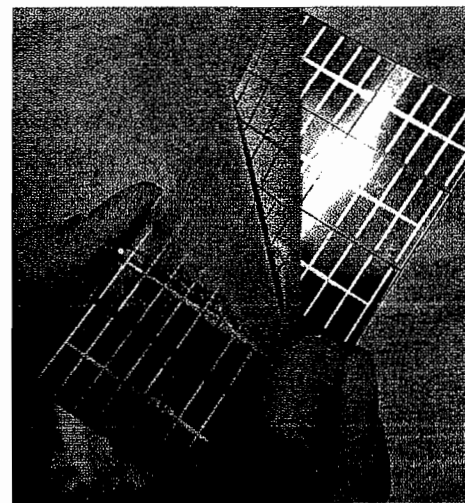
This reaction represents the most popular use of sulfuric acid, the industrial chemical produced in largest quantity.

SILICON

Silicon is a shiny, blue-gray, high-melting, brittle metalloid. It looks like a metal, but it is chemically more like a nonmetal. It is second only to oxygen in abundance in the earth’s crust, about 87% of which is composed of silica (SiO₂) and its derivatives, the silicate minerals. The crust is 26% Si, compared with 49.5% O. Silicon does not occur free in nature. Pure silicon crystallizes with a diamond-type structure, but the Si atoms are less closely packed than C atoms. Its density is 2.4 g/cm³ compared with 3.51 g/cm³ for diamond.



Superphosphate fertilizer.



Pure silicon is used in solar cells to collect energy from the sun.

Exhibit 3



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Book Series: Inorganic Reactions and Methods

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4.2. Homoatomic Bonds

4.2.2. Catenated Group VB Atoms

4.2.2.2. Involving Phosphorus-Phosphorus Bonds

4.2.2.2.2. In Phosphorus Allotropes.

The literature of phosphorus allotropy is complex and confusing and contains claims of the existence of forms of solid phosphorus that are invalid. However, at least three species of elemental phosphorus should be noted:

(i) **White Phosphorus**¹. These molecular crystals contain arrays of P₄ molecules as noted in §4.2.2.2.1. It is the least stable and most reactive of the phosphorus allotropes.

(ii) **Violet (or Red) Phosphorus**. White phosphorus can be converted to the more stable, crystalline violet (or red) phosphorus, which has a double-layer structure² consisting of cage-like P₈ and P₉ groups that are linked alternately by pairs of phosphorus atoms to form tubes having pentagonal cross sections. The double layers are formed from parallel tubes in which the tubes in adjacent layers are approximately perpendicular to each other. Each double layer of tubes consists of two interpenetrating systems of tubes that are not bonded chemically to each other. Further, there are no chemical bonds between adjacent double layers.

(iii) **Black Phosphorus**. When white phosphorus is subjected to a pressure of 12,000 kg cm⁻² (1200 MPa) at 200°C, it is converted to black phosphorus, which is the most stable of the phosphorus allotropes³. Black phosphorus has a graphite-like appearance and, like graphite, it is an electrical conductor. It is made up of puckered layers of phosphorus atoms, each of which is covalently bound with three other phosphorus atoms. The P—P bond lengths average 2.234 Å (223.4 pm) and the bond angles are 102° and 96° in a ratio of 2:1.

Vapor from red phosphorus, and presumably from white phosphorus at sufficiently high T, consists of P₂ molecules with a P≡P bond distance⁴ of 1.895 Å (189.5 pm).

(H. H. SISLER)

1. J. Donohue, *The Structure of the Elements*, Wiley, New York, 1974, p. 206.

2. H. Thurn, H. Krebs, *Acta Crystallogr. Sect. B*, **25**, 125 (1969).

3. P. W. Bridgman, *Acta Crystallogr.*, **19**, 684 (1965).

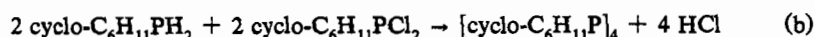
4. D. E. C. Corbridge, E. J. Lowe, *Nature (London)*, **170**, 629 (1952).

4.2.2.2.3. In Linear and Cyclic Di- and Polyphosphines.

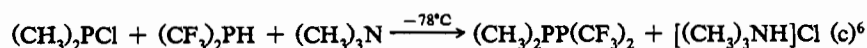
Diphosphines and polyphosphines, both linear and cyclic, are prepared by coupling reactions, e.g., dehydrohalogenation between a primary or secondary phosphine and a mono- or dihalophosphine, as in the synthesis¹ of (PhP)₃ or (PhP)₆ from PhPH₂ with PhPCl₂. The compound Me₂PPMe₂ is formed by^{2,3}:



Tetracyclohexyltetracyclophosphine is obtained in refluxing toluene⁴:



The tetraethyl compound is prepared by the same method⁵, which is also used to synthesize R₂PPR'₂ compounds, where R and R' are alkyl, perfluoroalkyl, aryl or amino groups. The reactions are run at reduced T, and tertiary amines are used to promote the removal of hydrogen halide, e.g.:



A variation⁷ yields pentaphenyltriphosphine:

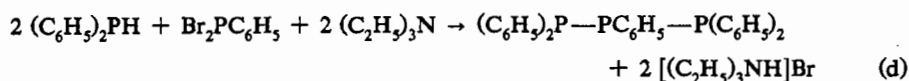
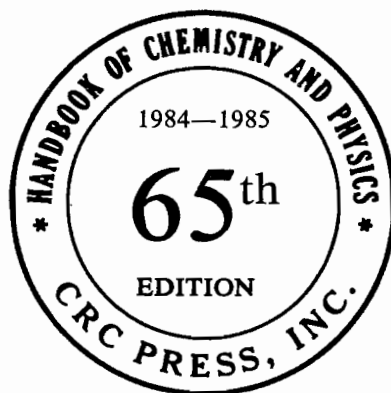


Exhibit 4

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A Ready-Reference Book of Chemical and Physical Data



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THE ELEMENTS (continued)

wt. 106.4; at. no. 46; m.p. 1554°C; b.p. 2970°C; sp. gr. 12.02 (20°C); valence 2, 3, or 4. Discovered in 1803 by Wollaston. Palladium is found along with platinum and other metals of the platinum group in placer deposits of the U.S.S.R., South and North America, Ethiopia, and Australia. It is also found associated with the nickel-copper deposits of South Africa and Ontario. Its separation from the platinum metals depends upon the type of ore in which it is found. It is a steel-white metal, does not tarnish in air, and is the least dense and lowest melting of the platinum group of metals. When annealed, it is soft and ductile; cold working greatly increases its strength and hardness. Palladium is attacked by nitric and sulfuric acid. At room temperatures the metal has the unusual property of absorbing up to 900 times its own volume of hydrogen, possibly forming Pd_2H . It is not yet clear if this is a true compound. Hydrogen readily diffuses through heated palladium and this provides a means of purifying the gas. Finely divided palladium is a good catalyst and is used for hydrogenation and dehydrogenation reactions. It is alloyed and used in jewelry trades. White gold is an alloy of gold decolorized by the addition of palladium. Like gold, palladium can be beaten into leaf as thin as 1/250,000 in. The metal is used in dentistry, watchmaking, and in making surgical instruments and electrical contacts. The metal sells for about \$100/tr. oz.

Phosphorus — (Gr. *phosphoros*, light bearing; ancient name for the planet Venus when appearing before sunrise), P; at. wt. 30.97376; at. no. 15; m.p. (white) 44.1°C; b.p. (white) 280°C; sp. gr. (white) 1.82, (red) 2.20, (black) 2.25 to 2.69; valence 3 or 5. Discovered in 1669 by Brand, who prepared it from urine. Phosphorus exists in four or more allotropic forms: white (or yellow), red, and black (or violet). White phosphorus has two modifications: α and β with a transition temperature at -3.8°C. Never found free in nature, it is widely distributed in combination with minerals. *Phosphate* rock, which contains the mineral *apatite*, an impure tri-calcium phosphate, is an important source of the element. Large deposits are found in the U.S.S.R., in Morocco, and in Florida, Tennessee, Utah, Idaho, and elsewhere. Phosphorus is an essential ingredient of all cell protoplasm, nervous tissue, and bones. Ordinary phosphorus is a waxy white solid; when pure it is colorless and transparent. It is insoluble in water, but soluble in carbon disulfide. It takes fire spontaneously in air, burning to the pentoxide. It is very poisonous, 50mg constituting an approximate fatal dose. Exposure to white phosphorus should not exceed 0.1mg/M³ (8-hr time-weighted average — 40-hr work week). White phosphorus should be kept under water, as it is dangerously reactive in air, and it should be handled with forceps, as contact with the skin may cause severe burns. When exposed to sunlight or when heated in its own vapor to 250°C, it is converted to the red variety, which does not phosphoresce in air as does the white variety. This form does not ignite spontaneously and it is not as dangerous as white phosphorus. It should, however, be handled with care as it does convert to the white form at some temperatures and it emits highly toxic fumes of the oxides of phosphorus when heated. The red modification is fairly stable, sublimes with a vapor pressure of 1 atm at 417°C, and is used in the manufacture of safety matches, pyrotechnics, pesticides, incendiary shells, smoke bombs, tracer bullets, etc. White phosphorus may be made by several methods. By one process, tri-calcium phosphate, the essential ingredient of phosphate rock, is heated in the presence of carbon and silica in an electric furnace or fuel-fired blast furnace. Elementary phosphorus is liberated as vapor and may be collected under water. If desired, the phosphorus vapor and carbon monoxide produced by the reaction can be oxidized at once in the presence of moisture or water to produce phosphoric acid, an important compound in making super-phosphate fertilizers. In recent years, concentrated phosphoric acids, which may contain as much as 70 to 75% P_2O_5 content, have become of great importance to agriculture and farm production. World-wide demand for fertilizers has caused record phosphate production in recent years. Phosphates are used in the production of special glasses, such as those used for sodium lamps. Bone-ash, calcium phosphate, is also used to produce fine chinaware and to produce mono-calcium phosphate used in baking powder. Phosphorus is also important in the production of steels, phosphor bronze, and many other products. Trisodium phosphate is important as a cleaning agent, as a water softener, and for preventing boiler scale and corrosion of pipes and boiler tubes. Organic compounds of phosphorus are important.

Platinum — (Sp. *platina*, silver), Pt; at. wt. 195.08 ± 3; at. no. 78; m.p. 1772°C; b.p. 3827 ± 100°C; sp. gr. 21.45 (20°C); valence 1?, 2, 3, or 4. Discovered in South America by Ulloa in 1735 and by Wood in 1741. The metal was used by pre-Columbian Indians. Platinum occurs native, accompanied by small quantities of iridium, osmium, palladium, ruthenium, and rhodium, all belonging to the same group of metals. These are found in the alluvial deposits of the Ural mountains, of Columbia, and of certain western American states. *Sperrylite* (PtAs_2), occurring with the nickel-bearing deposits of Sudbury, Ontario, is the source of a considerable amount of the metal. The large production of nickel offsets there being only one part of the platinum metals in two million parts of ore. Platinum is a beautiful silvery-white metal, when pure, and is malleable and ductile. It has a coefficient of expansion almost equal to that of soda-lime-silica glass, and is therefore used to make sealed electrodes in glass systems. The metal does not oxidize in air at any temperature, but is corroded by halogens, cyanides, sulfur, and caustic alkalis. It is insoluble in hydrochloric and nitric acid, but dissolves when they are mixed as *aqua regia*, forming chloroplatinic acid (H_2PtCl_6), an important compound. The metal is extensively used in jewelry, wire, and vessels for laboratory use, and in many valuable instruments including thermocouple elements. It is also used for electrical contacts, corrosion-resistant apparatus, and in dentistry. Platinum-cobalt alloys have magnetic properties. One such alloy made of 76.7% Pt and 23.3% Co, by weight, is an extremely powerful magnet that offers a B-H (max) almost twice that of Alnico V. Platinum resistance wires are used for constructing high-temperature electric furnaces. The metal is used for coating missile nose cones, jet engine fuel nozzles, etc., which must perform reliably for long periods of time at high temperatures. The metal, like palladium, absorbs large volumes of hydrogen, retaining it at ordinary temperatures but giving it up at red heat. In the finely divided state platinum is an excellent catalyst, having long been used in the contact process for producing sulfuric acid. It is also used as a catalyst in cracking petroleum products. There is also much current interest in the use of platinum as a catalyst in fuel cells and in antipollution devices for automobiles. Platinum anodes are extensively used in cathodic protection systems for large ships and ocean-going vessels, pipelines, steel piers, etc. Fine platinum wire will glow red hot when placed in the vapor of methyl alcohol. It acts here as a catalyst, converting the alcohol to formaldehyde. This phenomenon has been used commercially to produce cigarette lighters and hand warmers. Hydrogen and oxygen explode in the

Exhibit 5

CHEMISTRY FOR ENVIRONMENTAL ENGINEERING

Fourth Edition

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Sanitary Chemistry
Massachusetts Institute of Technology*

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94-261

TABLE 29-1
Phosphorus compounds commonly encountered
in environmental engineering practice

Name	Formula
Orthophosphates:	
Trisodium phosphate	Na_3PO_4
Disodium phosphate	Na_2HPO_4
Monosodium phosphate	NaH_2PO_4
Diammonium phosphate	$(\text{NH}_4)_2\text{HPO}_4$
Polyphosphates:	
Sodium hexametaphosphate	$\text{Na}_3(\text{PO}_3)_6$
Sodium tripolyphosphate	$\text{Na}_5\text{P}_3\text{O}_{10}$
Tetrasodium pyrophosphate	$\text{Na}_4\text{P}_2\text{O}_7$

purposes. The total phosphorus content of digested sludges is ordinarily about 1 percent and that of heat-dried activated sludge about 1.5 percent. In the United States, where phosphate fertilizers are relatively abundant and cheap, most sludges are sold on the basis of their nitrogen content, and little or no credit is given for the phosphorus.

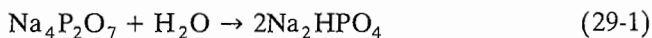
Boiler Waters

Phosphate compounds are widely used in steam power plants to control scaling in boilers. If complex phosphates are used, they are rapidly hydrolyzed to orthophosphate at the high temperatures involved. Control of phosphate levels is accomplished through determinations of orthophosphate.

29-2 PHOSPHORUS COMPOUNDS OF IMPORTANCE

Phosphorus compounds of wide variety are encountered in environmental engineering practice. A list of the more important ones is given in Table 29-1.

All the polyphosphates (molecularly dehydrated phosphates) gradually hydrolyze in aqueous solution and revert to the ortho form from which they were derived:



The rate of reversion is a function of temperature and increases rapidly as the temperature approaches the boiling point. The rate is also increased by lowering the pH, and advantage is taken of this fact in the preparation of samples for the determination of complex phosphates. The hydrolysis of complex phosphates is also influenced by bacterial enzymes. The rate of reversion is very slow in pure waters but is more rapid in wastewaters. Experiments have shown that pyrophosphates are hydrolyzed more rapidly than tripolyphosphates in some

Exhibit 6

SURFACE WATER-QUALITY MODELING

Steven C. Chapra

University of Colorado at Boulder



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SURFACE WATER-QUALITY MODELING

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phosphorus, serves to remove phosphorus from the water to the bottom sea. For cases where the water in contact with the sediments contains oxygen, sediment phosphorus becomes chemically trapped.

Although phosphorus is naturally scarce, many human activities result in phosphorus discharge to natural waters. Human and animal wastes both contain substantial amounts of phosphorus. In the recent past the former has been supplemented with detergent phosphorus. In addition nonpoint sources from agricultural and urban runoff both contribute excess phosphorus. Part of the enhancement of diffuse sources is due to fertilizers and other phosphorus-containing chemicals associated with land use. Moreover, human uses lead to soil erosion, which also enhances phosphorus transport into waters.

Phosphorus in natural waters can be subdivided in several ways. One scheme, which stems from conventional measurement techniques and modeling necessity, is (Fig. 28.1)

- **Soluble reactive phosphorus (SRP)**. Also called orthophosphate or soluble inorganic P, this is the form that is readily available to plants. It consists of the species H_2PO_4^- , HPO_4^{2-} , and PO_4^{3-} .
- **Particulate organic P**. This form mainly consists of living plants, animals, and bacteria as well as organic detritus.
- **Nonparticulate organic P**. These are dissolved or colloidal organic compounds containing phosphorus. Their primary origin is the decomposition of particulate organic P.
- **Particulate inorganic P**. This category consists of phosphate minerals (e.g., apatite phosphorus), sorbed orthophosphate (e.g., on clays), and phosphate complexed with solid matter (e.g., calcium carbonate precipitates or iron hydroxides).
- **Nonparticulate inorganic P**. This group includes condensed phosphates such as those found in detergents.

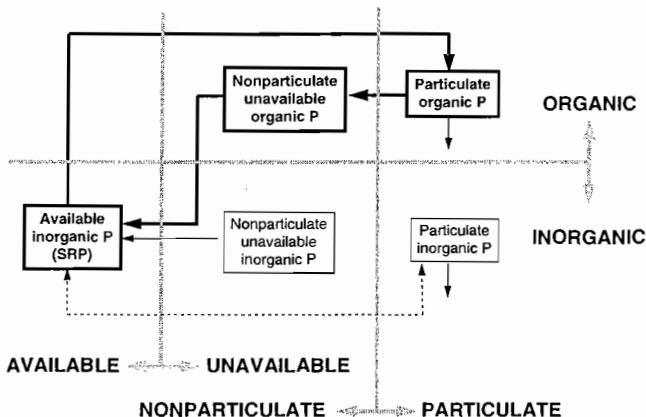


FIGURE 28.1

Forms of phosphorus found in natural waters. The principal forms involved in the production/decomposition life cycle are shown in bold.

Exhibit 7

USDA National Nutrient Database for Standard Reference, Release 21**Phosphorus, P (mg) Content of Selected Foods per Common Measure, sorted alphabetically**

NDB_No	Description	Weight (g)	Common Measure	Content per Measure
14006	Alcoholic beverage, beer, light	354	12 fl oz	42
14003	Alcoholic beverage, beer, regular, all	355	12 fl oz	50
14010	Alcoholic beverage, daiquiri, prepared-from-recipe	60	2 fl oz	3
14037	Alcoholic beverage, distilled, all (gin, rum, vodka, whiskey) 80 proof	42	1.5 fl oz	2
14550	Alcoholic beverage, distilled, all (gin, rum, vodka, whiskey) 86 proof	42	1.5 fl oz	2
14551	Alcoholic beverage, distilled, all (gin, rum, vodka, whiskey) 90 proof	42	1.5 fl oz	2
14414	Alcoholic beverage, liqueur, coffee, 53 proof	52	1.5 fl oz	3
14017	Alcoholic beverage, pina colada, prepared-from-recipe	141	4.5 fl oz	10
14536	Alcoholic beverage, wine, dessert, dry	103	3.5 fl oz	9
14057	Alcoholic beverage, wine, dessert, sweet	103	3.5 fl oz	9
14096	Alcoholic beverage, wine, table, red	103	3.5 fl oz	24
14106	Alcoholic beverage, wine, table, white	103	3.5 fl oz	19
11001	Alfalfa seeds, sprouted, raw	33	1 cup	23
09016	Apple juice, canned or bottled, unsweetened, without added ascorbic acid	248	1 cup	17
09011	Apples, dried, sulfured, uncooked	32	5 rings	12
09003	Apples, raw, with skin	138	1 apple	15
09004	Apples, raw, without skin	110	1 cup	12
09020	Applesauce, canned, sweetened, without salt (includes USDA commodity)	255	1 cup	15
09019	Applesauce, canned, unsweetened, without added ascorbic acid (includes USDA commodity)	244	1 cup	12
09403	Apricot nectar, canned, with added ascorbic acid	251	1 cup	23
09027	Apricots, canned, heavy syrup pack, with skin, solids and liquids	258	1 cup	31
09024	Apricots, canned, juice pack, with skin, solids and liquids	244	1 cup	49
09032	Apricots, dried, sulfured, uncooked	35	10 halves	25
09021	Apricots, raw	35	1 apricot	8
11008	Artichokes, (globe or french), cooked, boiled, drained, without salt	168	1 cup	123
11008	Artichokes, (globe or french), cooked, boiled, drained, without salt	120	1 medium	88
11015	Asparagus, canned, drained solids	72	4 spears	31
11012	Asparagus, cooked, boiled, drained	60	4 spears	32
11019	Asparagus, frozen, cooked, boiled, drained, without salt	60	4 spears	29
11019	Asparagus, frozen, cooked, boiled, drained, without salt	180	1 cup	88
09038	Avocados, raw, California	28.35	1 oz	15
09039	Avocados, raw, Florida	28.35	1 oz	11
18005	Bagels, cinnamon-raisin	71	3-1/2" bagel	71
18005	Bagels, cinnamon-raisin	89	4" bagel	89
18003	Bagels, egg	71	3-1/2" bagel	60
18003	Bagels, egg	89	4" bagel	75
18001	Bagels, plain, enriched, with calcium propionate (includes onion, poppy, sesame)	71	3-1/2" bagel	62
18001	Bagels, plain, enriched, with calcium propionate (includes onion, poppy, sesame)	89	4" bagel	77
19077	Baking chocolate, unsweetened, liquid	28.35	1 oz	96
19078	Baking chocolate, unsweetened, squares	28.35	1 square	113
11028	Bamboo shoots, canned, drained solids	131	1 cup	33
09040	Bananas, raw	150	1 cup	33
09040	Bananas, raw	118	1 banana	26
20006	Barley, pearled, cooked	157	1 cup	85
20005	Barley, pearled, raw	200	1 cup	442

USDA National Nutrient Database for Standard Reference, Release 21**Phosphorus, P (mg) Content of Selected Foods per Common Measure, sorted alphabetically**

NDB_No	Description	Weight (g)	Common Measure	Content per Measure
16006	Beans, baked, canned, plain or vegetarian	254	1 cup	188
16008	Beans, baked, canned, with franks	259	1 cup	269
16010	Beans, baked, canned, with pork and sweet sauce	253	1 cup	258
16011	Beans, baked, canned, with pork and tomato sauce	253	1 cup	293
16015	Beans, black, mature seeds, cooked, boiled, without salt	172	1 cup	241
16025	Beans, great northern, mature seeds, cooked, boiled, without salt	177	1 cup	292
16034	Beans, kidney, red, mature seeds, canned	256	1 cup	233
16033	Beans, kidney, red, mature seeds, cooked, boiled, without salt	177	1 cup	251
16038	Beans, navy, mature seeds, cooked, boiled, without salt	182	1 cup	262
16043	Beans, pinto, mature seeds, cooked, boiled, without salt	171	1 cup	251
11056	Beans, snap, green, canned, regular pack, drained solids	135	1 cup	27
11053	Beans, snap, green, cooked, boiled, drained, without salt	125	1 cup	36
11061	Beans, snap, green, frozen, cooked, boiled, drained without salt	135	1 cup	39
11932	Beans, snap, yellow, canned, regular pack, drained solids	135	1 cup	26
11724	Beans, snap, yellow, cooked, boiled, drained, without salt	125	1 cup	49
11732	Beans, snap, yellow, frozen, cooked, boiled, drained, without salt	135	1 cup	42
16051	Beans, white, mature seeds, canned	262	1 cup	238
22402	Beef Macaroni, frozen entree	240	1 package	134
22905	Beef stew, canned entree	232	1 cup	128
13818	Beef, chuck, blade roast, separable lean and fat, trimmed to 1/8" fat, choice, cooked, braised	85	3 oz	168
13348	Beef, cured, corned beef, canned	85.05	3 oz	94
13350	Beef, cured, dried	28.35	1 oz	51
23578	Beef, ground, 75% lean meat / 25% fat, patty, cooked, broiled	85	3 oz	161
23573	Beef, ground, 80% lean meat / 20% fat, patty, cooked, broiled	85	3 oz	165
23568	Beef, ground, 85% lean meat / 15% fat, patty, cooked, broiled	85	3 oz	168
13869	Beef, round, bottom round, separable lean and fat, trimmed to 1/8" fat, all grades, cooked, braised	85	3 oz	173
23605	Beef, round, bottom round, separable lean only, trimmed to 1/8" fat, all grades, cooked, braised	85	3 oz	184
13878	Beef, round, eye of round, separable lean and fat, trimmed to 1/8" fat, all grades, cooked, roasted	85	3 oz	148
23598	Beef, round, eye of round, separable lean only, trimmed to 1/8" fat, all grades, cooked, roasted	85	3 oz	158
13930	Beef, top sirloin, separable lean and fat, trimmed to 1/8" fat, all grades, cooked, broiled	85	3 oz	178
23610	Beef, top sirloin, separable lean only, trimmed to 1/8" fat, all grades, cooked, broiled	85	3 oz	198
13327	Beef, variety meats and by-products, liver, cooked, pan-fried	85	3 oz	412
11087	Beet greens, cooked, boiled, drained, without salt	144	1 cup	59
11084	Beets, canned, drained solids	170	1 cup	29
11084	Beets, canned, drained solids	24	1 beet	4
11081	Beets, cooked, boiled, drained	170	1 cup	65
11081	Beets, cooked, boiled, drained	50	1 beet	19
18016	Biscuits, plain or buttermilk, prepared from recipe	101	4" biscuit	166
18016	Biscuits, plain or buttermilk, prepared from recipe	60	2-1/2" biscuit	98
18015	Biscuits, plain or buttermilk, refrigerated dough, higher fat, baked	27	2-1/2" biscuit	138
18013	Biscuits, plain or buttermilk, refrigerated dough, lower fat, baked	21	2-1/4" biscuit	98
09042	Blackberries, raw	144	1 cup	32
09055	Blueberries, frozen, sweetened	230	1 cup	16
09050	Blueberries, raw	145	1 cup	17

USDA National Nutrient Database for Standard Reference, Release 21**Phosphorus, P (mg) Content of Selected Foods per Common Measure, sorted alphabetically**

NDB_No	Description	Weight (g)	Common Measure	Content per Measure
07008	Bologna, beef and pork	56.7	2 slices	92
07014	Braunschweiger (a liver sausage), pork	56.7	2 slices	95
18079	Bread crumbs, dry, grated, plain	28.35	1 oz	47
18376	Bread crumbs, dry, grated, seasoned	120	1 cup	212
18082	Bread stuffing, bread, dry mix, prepared	100	1/2 cup	42
18019	Bread, banana, prepared from recipe, made with margarine	60	1 slice	35
18023	Bread, cornbread, dry mix, prepared	60	1 piece	226
18024	Bread, cornbread, prepared from recipe, made with low fat (2%) milk	65	1 piece	110
18025	Bread, cracked-wheat	25	1 slice	38
18027	Bread, egg	40	1/2" slice	42
18029	Bread, french or vienna (includes sourdough)	25	1/2" slice	29
18033	Bread, italian	20	1 slice	21
18035	Bread, Multi-Grain (includes whole-grain)	26	1 slice	59
18036	Bread, Multi-Grain, toasted (includes whole-grain)	24	1 slice	59
18039	Bread, oatmeal	27	1 slice	34
18040	Bread, oatmeal, toasted	25	1 slice	34
18041	Bread, pita, white, enriched	28	4" pita	27
18041	Bread, pita, white, enriched	60	6-1/2" pita	58
18044	Bread, pumpernickel	32	1 slice	57
18045	Bread, pumpernickel, toasted	29	1 slice	57
18047	Bread, raisin, enriched	26	1 slice	28
18048	Bread, raisin, toasted, enriched	24	1 slice	28
18053	Bread, reduced-calorie, rye	23	1 slice	18
18055	Bread, reduced-calorie, wheat	23	1 slice	23
18057	Bread, reduced-calorie, white	23	1 slice	28
18060	Bread, rye	32	1 slice	40
18061	Bread, rye, toasted	24	1 slice	33
18064	Bread, wheat	25	1 slice	39
18065	Bread, wheat, toasted	23	1 slice	43
18069	Bread, white, commercially prepared (includes soft bread crumbs)	25	1 slice	25
18069	Bread, white, commercially prepared (includes soft bread crumbs)	45	1 cup	45
18070	Bread, white, commercially prepared, toasted	22	1 slice	23
18075	Bread, whole-wheat, commercially prepared	28	1 slice	57
18076	Bread, whole-wheat, commercially prepared, toasted	25	1 slice	76
11091	Broccoli, cooked, boiled, drained, without salt	37	1 spear	25
11091	Broccoli, cooked, boiled, drained, without salt	156	1 cup	105
11740	Broccoli, flower clusters, raw	11	1 floweret	7
11093	Broccoli, frozen, chopped, cooked, boiled, drained, without salt	184	1 cup	90
11090	Broccoli, raw	31	1 spear	20
11090	Broccoli, raw	88	1 cup	58
11099	Brussels sprouts, cooked, boiled, drained, without salt	156	1 cup	87
11101	Brussels sprouts, frozen, cooked, boiled, drained, without salt	155	1 cup	87
20011	Buckwheat flour, whole-groat	120	1 cup	404
20010	Buckwheat groats, roasted, cooked	168	1 cup	118
20013	Bulgur, cooked	182	1 cup	73
20012	Bulgur, dry	140	1 cup	420
01001	Butter, salted	14.2	1 tbs	3
01145	Butter, without salt	14.2	1 tbs	3

USDA National Nutrient Database for Standard Reference, Release 21**Phosphorus, P (mg) Content of Selected Foods per Common Measure, sorted alphabetically**

NDB_No	Description	Weight (g)	Common Measure	Content per Measure
11117	Cabbage, chinese (pak-choi), cooked, boiled, drained, without salt	170	1 cup	49
11120	Cabbage, chinese (pe-tsai), cooked, boiled, drained, without salt	119	1 cup	46
11110	Cabbage, cooked, boiled, drained, without salt	150	1 cup	50
11109	Cabbage, raw	70	1 cup	18
11112	Cabbage, red, raw	70	1 cup	21
11114	Cabbage, savoy, raw	70	1 cup	29
18086	Cake, angelfood, commercially prepared	28	1 piece	91
18088	Cake, angelfood, dry mix, prepared	50	1 piece	116
18090	Cake, boston cream pie, commercially prepared	92	1 piece	45
18096	Cake, chocolate, commercially prepared with chocolate frosting	64	1 piece	78
18101	Cake, chocolate, prepared from recipe without frosting	95	1 piece	101
18110	Cake, fruitcake, commercially prepared	43	1 piece	22
18116	Cake, gingerbread, prepared from recipe	74	1 piece	40
18119	Cake, pineapple upside-down, prepared from recipe	115	1 piece	94
18120	Cake, pound, commercially prepared, butter	28	1 piece	38
18451	Cake, pound, commercially prepared, fat-free	28	1 slice	41
18126	Cake, shortcake, biscuit-type, prepared from recipe	65	1 shortcake	93
18127	Cake, snack cakes, creme-filled, chocolate with frosting	50	1 cupcake	44
18128	Cake, snack cakes, creme-filled, sponge	42.5	1 cake	79
18452	Cake, snack cakes, cupcakes, chocolate, with frosting, low-fat	43	1 cupcake	79
18133	Cake, sponge, commercially prepared	30	1 shortcake	41
18134	Cake, sponge, prepared from recipe	63	1 piece	63
18102	Cake, white, prepared from recipe with coconut frosting	112	1 piece	78
18139	Cake, white, prepared from recipe without frosting	74	1 piece	69
18140	Cake, yellow, commercially prepared, with chocolate frosting	64	1 piece	103
18141	Cake, yellow, commercially prepared, with vanilla frosting	64	1 piece	92
19074	Candies, caramels	10.1	1 piece	12
19076	Candies, caramels, chocolate-flavor roll	7	1 piece	4
19071	Candies, carob, unsweetened	28.35	1 oz	36
19100	Candies, fudge, chocolate, prepared-from-recipe	17	1 piece	12
19101	Candies, fudge, chocolate, with nuts, prepared-from-recipe	19	1 piece	22
19104	Candies, fudge, vanilla with nuts	15	1 piece	11
19103	Candies, fudge, vanilla, prepared-from-recipe	16	1 piece	5
19106	Candies, gumdrops, starch jelly pieces	22	10 bears	0
19106	Candies, gumdrops, starch jelly pieces	4.2	1 medium	0
19106	Candies, gumdrops, starch jelly pieces	74	10 worms	1
19107	Candies, hard	6	1 piece	0
19107	Candies, hard	3	1 small piece	0
19108	Candies, jellybeans	28.35	10 large	1
19109	Candies, KIT KAT Wafer Bar	42	1 bar (1.5 oz)	57
19116	Candies, marshmallows	50	1 cup	4
19141	Candies, MASTERFOODS USA, M&M's Milk Chocolate Candies	7	10 pieces	10
19140	Candies, MASTERFOODS USA, M&M's Peanut Chocolate Candies	20	10 pieces	38
19135	Candies, MASTERFOODS USA, MILKY WAY Bar	61	1 bar (2.15 oz)	41
19135	Candies, MASTERFOODS USA, MILKY WAY Bar	18	1 fun size bar	12
19155	Candies, MASTERFOODS USA, SNICKERS Bar	57	1 bar (2 oz)	108
19156	Candies, MASTERFOODS USA, STARBURST Fruit Chews, Original fruits	5	1 piece	0
19120	Candies, milk chocolate	44	1 bar (1.55 oz)	92

USDA National Nutrient Database for Standard Reference, Release 21**Phosphorus, P (mg) Content of Selected Foods per Common Measure, sorted alphabetically**

NDB_No	Description	Weight (g)	Common Measure	Content per Measure
19126	Candies, milk chocolate coated peanuts	40	10 pieces	85
19127	Candies, milk chocolate coated raisins	10	10 pieces	14
19132	Candies, milk chocolate, with almonds	41	1 bar (1.45 oz)	108
19143	Candies, MR. GOODBAR Chocolate Bar	49	1 bar (1.75 oz)	80
19069	Candies, NESTLE, BUTTERFINGER Bar	7	1 fun size bar	7
19150	Candies, REESE'S Peanut Butter Cups	45	1 package (contains 2)	72
19080	Candies, semisweet chocolate	168	1 cup	222
19164	Candies, SPECIAL DARK Chocolate Bar	8.4	1 miniature	4
19087	Candies, white chocolate	170	1 cup	299
09060	Carambola, (starfruit), raw	91	1 fruit	11
09060	Carambola, (starfruit), raw	108	1 cup	13
14121	Carbonated beverage, club soda	355	12 fl oz	0
14400	Carbonated beverage, cola, contains caffeine	370	12 fl oz	37
14136	Carbonated beverage, ginger ale	366	12 fl oz	0
14142	Carbonated beverage, grape soda	372	12 fl oz	0
14416	Carbonated beverage, low calorie, cola or pepper-type, with aspartame, contains caffeine	355	12 fl oz	32
14143	Carbonated beverage, low calorie, other than cola or pepper, without caffeine	355	12 fl oz	0
14150	Carbonated beverage, orange	372	12 fl oz	4
14153	Carbonated beverage, pepper-type, contains caffeine	368	12 fl oz	40
14157	Carbonated beverage, root beer	370	12 fl oz	0
14145	Carbonated beverage, SPRITE, lemon-lime, without caffeine	368	12 fl oz	0
16055	Carob flour	8	1 tbsp	6
11655	Carrot juice, canned	236	1 cup	99
11960	Carrots, baby, raw	10	1 medium	3
11128	Carrots, canned, regular pack, drained solids	146	1 cup	35
11125	Carrots, cooked, boiled, drained, without salt	156	1 cup	47
11131	Carrots, frozen, cooked, boiled, drained, without salt	146	1 cup	45
11124	Carrots, raw	110	1 cup	39
11124	Carrots, raw	72	1 carrot	25
11935	Catsup	6	1 packet	2
11935	Catsup	15	1 tbsp	5
11136	Cauliflower, cooked, boiled, drained, without salt	124	1 cup	40
11136	Cauliflower, cooked, boiled, drained, without salt	54	3 flowerets	17
11138	Cauliflower, frozen, cooked, boiled, drained, without salt	180	1 cup	43
11135	Cauliflower, raw	100	1 cup	44
11135	Cauliflower, raw	13	1 floweret	6
11144	Celery, cooked, boiled, drained, without salt	37.5	1 stalk	9
11144	Celery, cooked, boiled, drained, without salt	150	1 cup	38
11143	Celery, raw	120	1 cup	29
11143	Celery, raw	40	1 stalk	10
08263	Cereals ready-to-eat, GENERAL MILLS, APPLE CINNAMON CHEERIOS	30	3/4 cup	60
08262	Cereals ready-to-eat, GENERAL MILLS, BASIC 4	55	1 cup	100
08274	Cereals ready-to-eat, GENERAL MILLS, BERRY BERRY KIX	30	3/4 cup	40
08013	Cereals ready-to-eat, GENERAL MILLS, CHEERIOS	30	1 cup	131
08272	Cereals ready-to-eat, GENERAL MILLS, CINNAMON TOAST CRUNCH	30	3/4 cup	48
08271	Cereals ready-to-eat, GENERAL MILLS, COCOA PUFFS	30	1 cup	20

USDA National Nutrient Database for Standard Reference, Release 21**Phosphorus, P (mg) Content of Selected Foods per Common Measure, sorted alphabetically**

NDB_No	Description	Weight (g)	Common Measure	Content per Measure
08019	Cereals ready-to-eat, GENERAL MILLS, Corn CHEX	30	1 cup	22
08035	Cereals ready-to-eat, GENERAL MILLS, GOLDEN GRAHAMS	30	3/4 cup	40
08045	Cereals ready-to-eat, GENERAL MILLS, HONEY NUT CHEERIOS	30	1 cup	107
08057	Cereals ready-to-eat, GENERAL MILLS, Honey Nut CHEX	30	3/4 cup	20
08243	Cereals ready-to-eat, GENERAL MILLS, HONEY NUT CLUSTERS	55	1 cup	80
08048	Cereals ready-to-eat, GENERAL MILLS, KIX	30	1-1/3 cup	57
08050	Cereals ready-to-eat, GENERAL MILLS, LUCKY CHARMS	30	1 cup	71
08261	Cereals ready-to-eat, GENERAL MILLS, RAISIN NUT BRAN	55	1 cup	150
08194	Cereals ready-to-eat, GENERAL MILLS, REESE'S PUFFS	30	3/4 cup	60
08064	Cereals ready-to-eat, GENERAL MILLS, Rice CHEX	31	1-1/4 cup	35
08246	Cereals ready-to-eat, GENERAL MILLS, TOTAL Corn Flakes	30	1-1/3 cup	110
08247	Cereals ready-to-eat, GENERAL MILLS, TOTAL Raisin Bran	55	1 cup	100
08078	Cereals ready-to-eat, GENERAL MILLS, TRIX	30	1 cup	38
08082	Cereals ready-to-eat, GENERAL MILLS, Wheat CHEX	30	1 cup	90
08089	Cereals ready-to-eat, GENERAL MILLS, WHEATIES	30	1 cup	100
08077	Cereals ready-to-eat, GENERAL MILLS, Whole Grain TOTAL	30	3/4 cup	80
08028	Cereals ready-to-eat, KELLOGG, KELLOGG'S ALL-BRAN COMPLETE Wheat Flakes	29	3/4 cup	139
08001	Cereals ready-to-eat, KELLOGG, KELLOGG'S ALL-BRAN Original	30	1/2 cup	345
08003	Cereals ready-to-eat, KELLOGG, KELLOGG'S APPLE JACKS	30	1 cup	23
08014	Cereals ready-to-eat, KELLOGG, KELLOGG'S COCOA KRISPIES	31	3/4 cup	32
08020	Cereals ready-to-eat, KELLOGG, KELLOGG'S Corn Flakes	28	1 cup	10
08068	Cereals ready-to-eat, KELLOGG, KELLOGG'S CORN POPS	31	1 cup	10
08259	Cereals ready-to-eat, KELLOGG, KELLOGG'S CRISPIX	29	1 cup	28
08030	Cereals ready-to-eat, KELLOGG, KELLOGG'S FROOT LOOPS	30	1 cup	19
08069	Cereals ready-to-eat, KELLOGG, KELLOGG'S FROSTED FLAKES	31	3/4 cup	13
08319	Cereals ready-to-eat, KELLOGG, KELLOGG'S FROSTED MINI-WHEATS, bite size	55	1 cup	162
08071	Cereals ready-to-eat, KELLOGG, KELLOGG'S Honey SMACKS	27	3/4 cup	46
08058	Cereals ready-to-eat, KELLOGG, KELLOGG'S PRODUCT 19	30	1 cup	40
08060	Cereals ready-to-eat, KELLOGG, KELLOGG'S RAISIN BRAN	61	1 cup	223
08065	Cereals ready-to-eat, KELLOGG, KELLOGG'S RICE KRISPIES	33	1-1/4 cup	42
08288	Cereals ready-to-eat, KELLOGG, KELLOGG'S RICE KRISPIES TREATS Cereal	30	3/4 cup	24
08067	Cereals ready-to-eat, KELLOGG, KELLOGG'S SPECIAL K	31	1 cup	68
08031	Cereals ready-to-eat, KELLOGG'S FROSTED MINI-WHEATS, original	51	1 cup	153
08010	Cereals ready-to-eat, QUAKER, CAP'N CRUNCH	27	3/4 cup	45
08011	Cereals ready-to-eat, QUAKER, CAP'N CRUNCH with CRUNCHBERRIES	26	3/4 cup	43
08012	Cereals ready-to-eat, QUAKER, CAP'N CRUNCH'S PEANUT BUTTER CRUNCH	27	3/4 cup	53
08220	Cereals ready-to-eat, QUAKER, Low Fat 100% Natural Granola with Raisins	50	1/2 cup	134
08218	Cereals ready-to-eat, QUAKER, QUAKER 100% Natural Cereal with oats, honey, and raisins	51	1/2 cup	168
08210	Cereals ready-to-eat, QUAKER, QUAKER OAT CINNAMON LIFE	32	3/4 cup	120
08049	Cereals ready-to-eat, QUAKER, QUAKER OAT LIFE, plain	32	3/4 cup	132
08219	Cereals ready-to-eat, QUAKER, QUAKER toasted Oatmeal Cereal, Honey Nut	49	1 cup	118
08156	Cereals ready-to-eat, rice, puffed, fortified	14	1 cup	14
08084	Cereals ready-to-eat, wheat germ, toasted, plain	7.119	1 tbsp	82

USDA National Nutrient Database for Standard Reference, Release 21**Phosphorus, P (mg) Content of Selected Foods per Common Measure, sorted alphabetically**

NDB_No	Description	Weight (g)	Common Measure	Content per Measure
08157	Cereals ready-to-eat, wheat, puffed, fortified	12	1 cup	43
08147	Cereals ready-to-eat, wheat, shredded, plain, sugar and salt free	46	2 biscuits	170
08091	Cereals, corn grits, white, regular and quick, enriched, cooked with water, without salt	242	1 cup	27
08164	Cereals, corn grits, yellow, regular and quick, enriched, cooked with water, without salt	242	1 cup	27
08109	Cereals, CREAM OF WHEAT, mix'n eat, plain, prepared with water	142	1 packet	20
08105	Cereals, CREAM OF WHEAT, quick, cooked with water, without salt	239	1 cup	100
08103	Cereals, CREAM OF WHEAT, regular, cooked with water, without salt	251	1 cup	43
08511	Cereals, Malt-o-Meal, plain, prepared with water, without salt	268	1serving (3 T dry cereal plu	67
08123	Cereals, oats, instant, fortified, plain, prepared with water (boiling water added or microwaved)	177	1 packet	136
08121	Cereals, oats, regular and quick and instant, unenriched, cooked with water (includes boiling and microwaving), without salt	234	1 cup	180
08093	Cereals, QUAKER, corn grits, instant, plain, prepared with water	137	1 packet	29
08131	Cereals, QUAKER, Instant Oatmeal, maple and brown sugar, prepared with boiling water	155	1 packet	129
08125	Cereals, QUAKER,Instant Oatmeal, apples and cinnamon, prepared with boiling water	149	1 packet	94
08143	Cereals, WHEATENA, cooked with water	243	1 cup	146
01046	Cheese food, pasteurized process, american, without di sodium phosphate	28.35	1 oz	124
01164	Cheese sauce, prepared from recipe	243	1 cup	556
01048	Cheese spread, pasteurized process, american, without di sodium phosphate	28.35	1 oz	202
01004	Cheese, blue	28.35	1 oz	110
01007	Cheese, camembert	38	1 wedge	132
01009	Cheese, cheddar	28.35	1 oz	145
01012	Cheese, cottage, creamed, large or small curd	210	1 cup	334
01013	Cheese, cottage, creamed, with fruit	226	1 cup	255
01016	Cheese, cottage, lowfat, 1% milkfat	226	1 cup	303
01015	Cheese, cottage, lowfat, 2% milkfat	226	1 cup	368
01014	Cheese, cottage, nonfat, uncreamed, dry, large or small curd	145	1 cup	276
01017	Cheese, cream	14.5	1 tbsp	15
01186	Cheese, cream, fat free	15.6	1 tbsp	82
01019	Cheese, feta	28.35	1 oz	96
01168	Cheese, low fat, cheddar or colby	28.35	1 oz	137
01029	Cheese, mozzarella, part skim milk, low moisture	28.35	1 oz	149
01026	Cheese, mozzarella, whole milk	28.35	1 oz	100
01030	Cheese, muenster	28.35	1 oz	133
01031	Cheese, neufchatel	28.35	1 oz	39
01032	Cheese, parmesan, grated	5	1 tbsp	36
01042	Cheese, pasteurized process, american, with di sodium phosphate	28.35	1 oz	145
01044	Cheese, pasteurized process, swiss, with di sodium phosphate	28.35	1 oz	216
01035	Cheese, provolone	28.35	1 oz	141
01037	Cheese, ricotta, part skim milk	246	1 cup	450
01036	Cheese, ricotta, whole milk	246	1 cup	389
01040	Cheese, swiss	28.35	1 oz	161
18147	Cheesecake commercially prepared	80	1 piece	74
09064	Cherries, sour, red, canned, water pack, solids and liquids (includes USDA commodity red tart cherries, canned)	244	1 cup	24
09070	Cherries, sweet, raw	68	10 cherries	14

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
22906	Chicken pot pie, frozen entree, prepared	217	1 small pie	178
07017	Chicken roll, light meat	56.7	2 slices	168
05058	Chicken, broilers or fryers, breast, meat and skin, cooked, fried, batter	140	1/2 breast	259
05059	Chicken, broilers or fryers, breast, meat and skin, cooked, fried, flour	98	1/2 breast	228
05064	Chicken, broilers or fryers, breast, meat only, cooked, roasted	86	1/2 breast	196
05044	Chicken, broilers or fryers, dark meat, meat only, cooked, fried	84	3 oz	157
05067	Chicken, broilers or fryers, drumstick, meat and skin, cooked, fried, batter	72	1 drumstick	106
05068	Chicken, broilers or fryers, drumstick, meat and skin, cooked, fried, flour	49	1 drumstick	86
05073	Chicken, broilers or fryers, drumstick, meat only, cooked, roasted	44	1 drumstick	81
05022	Chicken, broilers or fryers, giblets, cooked, simmered	145	1 cup	419
05040	Chicken, broilers or fryers, light meat, meat only, cooked, fried	84	3 oz	194
05090	Chicken, broilers or fryers, neck, meat only, cooked, simmered	18	1 neck	23
05092	Chicken, broilers or fryers, thigh, meat and skin, cooked, fried, batter	86	1 thigh	133
05098	Chicken, broilers or fryers, thigh, meat only, cooked, roasted	52	1 thigh	95
05101	Chicken, broilers or fryers, wing, meat and skin, cooked, fried, batter	49	1 wing	59
05277	Chicken, canned, meat only, with broth	142	5 oz	158
05028	Chicken, liver, all classes, cooked, simmered	19.6	1 liver	79
05126	Chicken, stewing, meat only, cooked, stewed	140	1 cup	286
16058	Chickpeas (garbanzo beans, bengal gram), mature seeds, canned	240	1 cup	216
16057	Chickpeas (garbanzo beans, bengal gram), mature seeds, cooked, boiled, without salt	164	1 cup	276
22904	Chili con carne with beans, canned entree	222	1 cup	215
11156	Chives, raw	3	1 tbsp	2
14181	Chocolate syrup	18.75	1 tbsp	24
14175	Chocolate-flavor beverage mix for milk, powder, without added nutrients	21.6	2-3 heaping tsp	28
14177	Chocolate-flavor beverage mix, powder, prepared with whole milk	266	1 cup	234
14196	Cocoa mix, no sugar added, powder	15	1/2 oz envelope	134
14192	Cocoa mix, powder	28.35	3 heaping tsp	89
14194	Cocoa mix, powder, prepared with water	206	1 serving	89
14390	Cocoa mix, with aspartame, powder, prepared with water	192	1 serving	134
19165	Cocoa, dry powder, unsweetened	5.4	1 tbsp	40
14209	Coffee, brewed from grounds, prepared with tap water	178	6 fl oz	5
14210	Coffee, brewed, espresso, restaurant-prepared	60	2 fl oz	4
14215	Coffee, instant, regular, prepared with water	179	6 fl oz	5
18104	Coffee cake, cinnamon with crumb topping, commercially prepared, enriched	63	1 piece	68
11159	Coleslaw, home-prepared	120	1 cup	38
11162	Collards, cooked, boiled, drained, without salt	190	1 cup	57
11164	Collards, frozen, chopped, cooked, boiled, drained, without salt	170	1 cup	46
18151	Cookies, brownies, commercially prepared	56	1 brownie	57
18197	Cookies, brownies, dry mix, special dietary, prepared	22	1 brownie	11
18155	Cookies, butter, commercially prepared, enriched	5	1 cookie	5
18159	Cookies, chocolate chip, commercially prepared, regular, higher fat, enriched	10	1 cookie	8
18158	Cookies, chocolate chip, commercially prepared, regular, lower fat	10	1 cookie	8
18165	Cookies, chocolate chip, prepared from recipe, made with margarine	16	1 cookie	16
18164	Cookies, chocolate chip, refrigerated dough, baked	26	1 cookie	20
18166	Cookies, chocolate sandwich, with creme filling, regular	10	1 cookie	10

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
18170	Cookies, fig bars	16	1 cookie	10
18173	Cookies, graham crackers, plain or honey (includes cinnamon)	14	2 squares	15
18173	Cookies, graham crackers, plain or honey (includes cinnamon)	84	1 cup	87
18177	Cookies, molasses	15	1 cookie, medium	14
18177	Cookies, molasses	32	1 cookie, large (3-1/2" to 4"	30
18456	Cookies, oatmeal, commercially prepared, fat-free	11	1 cookie	12
18178	Cookies, oatmeal, commercially prepared, regular	25	1 cookie	35
18179	Cookies, oatmeal, commercially prepared, soft-type	15	1 cookie	31
18184	Cookies, oatmeal, prepared from recipe, with raisins	15	1 cookie	24
18185	Cookies, peanut butter, commercially prepared, regular	15	1 cookie	13
18189	Cookies, peanut butter, prepared from recipe	20	1 cookie	23
18193	Cookies, shortbread, commercially prepared, pecan	14	1 cookie	12
18192	Cookies, shortbread, commercially prepared, plain	8	1 cookie	9
18204	Cookies, sugar, commercially prepared, regular (includes vanilla)	15	1 cookie	12
18208	Cookies, sugar, prepared from recipe, made with margarine	14	1 cookie	13
18206	Cookies, sugar, refrigerated dough, baked	15	1 cookie	28
18210	Cookies, vanilla sandwich with creme filling	10	1 cookie	8
18210	Cookies, vanilla sandwich with creme filling	15	1 cookie	11
18212	Cookies, vanilla wafers, lower fat	4	1 cookie	4
11901	Corn, sweet, white, cooked, boiled, drained, without salt	77	1 ear	79
11174	Corn, sweet, yellow, canned, cream style, regular pack	256	1 cup	131
11176	Corn, sweet, yellow, canned, vacuum pack, regular pack	210	1 cup	134
11168	Corn, sweet, yellow, cooked, boiled, drained, without salt	77	1 ear	58
11179	Corn, sweet, yellow, frozen, kernels cut off cob, boiled, drained, without salt	164	1 cup	130
11181	Corn, sweet, yellow, frozen, kernels on cob, cooked, boiled, drained, without salt	63	1 ear	47
20022	Cornmeal, degermed, enriched, yellow	138	1 cup	145
20025	Cornmeal, self-rising, degermed, enriched, yellow	138	1 cup	860
20020	Cornmeal, whole-grain, yellow	122	1 cup	294
20027	Cornstarch	8.064	1 tbsp	1
20029	Couscous, cooked	157	1 cup	35
20028	Couscous, dry	173	1 cup	294
11192	Cowpeas (Blackeyes), immature seeds, cooked, boiled, drained, without salt	165	1 cup	84
11196	Cowpeas (blackeyes), immature seeds, frozen, cooked, boiled, drained, without salt	170	1 cup	207
16064	Cowpeas, common (blackeyes, crowder, southern), mature seeds, canned, plain	240	1 cup	168
16063	Cowpeas, common (blackeyes, crowder, southern), mature seeds, cooked, boiled, without salt	172	1 cup	268
18214	Crackers, cheese, regular	10	10 crackers	22
18215	Crackers, cheese, sandwich-type with peanut butter filling	7	1 sandwich	19
18217	Crackers, matzo, plain	28.35	1 matzo	25
18220	Crackers, melba toast, plain	20	4 pieces	39
18226	Crackers, rye, wafers, plain	11	1 wafer	37
18228	Crackers, saltines (includes oyster, soda, soup)	12	4 crackers	13
18229	Crackers, standard snack-type, regular	12	4 crackers	31
18230	Crackers, standard snack-type, sandwich, with cheese filling	7	1 sandwich	28
18232	Crackers, wheat, regular	8	4 crackers	18
18235	Crackers, whole-wheat	16	4 crackers	47

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
14242	Cranberry juice cocktail, bottled	253	8 fl oz	3
09081	Cranberry sauce, canned, sweetened	57	1 slice	3
01067	Cream substitute, liquid, with hydrogenated vegetable oil and soy protein	15	1 tbsp	10
01069	Cream substitute, powdered	2	1 tsp	8
01049	Cream, fluid, half and half	15	1 tbsp	14
01053	Cream, fluid, heavy whipping	15	1 tbsp	9
01050	Cream, fluid, light (coffee cream or table cream)	15	1 tbsp	12
01052	Cream, fluid, light whipping	15	1 tbsp	9
01056	Cream, sour, cultured	12	1 tbsp	14
01055	Cream, sour, reduced fat, cultured	15	1 tbsp	14
01054	Cream, whipped, cream topping, pressurized	3	1 tbsp	3
18239	Croissants, butter	57	1 croissant	60
18243	Croutons, seasoned	40	1 cup	56
15137	Crustaceans, crab, alaska king, cooked, moist heat	85	3 oz	238
15138	Crustaceans, crab, alaska king, imitation, made from surimi	85	3 oz	240
15141	Crustaceans, crab, blue, canned	135	1 cup	351
15140	Crustaceans, crab, blue, cooked, moist heat	85	3 oz	175
15142	Crustaceans, crab, blue, crab cakes	60	1 cake	128
15148	Crustaceans, lobster, northern, cooked, moist heat	85	3 oz	157
15152	Crustaceans, shrimp, mixed species, canned	85.05	3 oz	166
15150	Crustaceans, shrimp, mixed species, cooked, breaded and fried	45	6 large	98
15150	Crustaceans, shrimp, mixed species, cooked, breaded and fried	85	3 oz	185
11206	Cucumber, peeled, raw	280	1 large	59
11206	Cucumber, peeled, raw	119	1 cup	25
11205	Cucumber, with peel, raw	104	1 cup	25
11205	Cucumber, with peel, raw	301	1 large	72
11208	Dandelion greens, cooked, boiled, drained, without salt	105	1 cup	44
18245	Danish pastry, cheese	71	1 danish	77
18246	Danish pastry, fruit, enriched (includes apple, cinnamon, raisin, lemon, raspberry, strawberry)	71	1 danish	63
09087	Dates, deglet noor	41.5	5 dates	26
09087	Dates, deglet noor	178	1 cup	110
01071	Dessert topping, powdered, 1.5 ounce prepared with 1/2 cup milk	4	1 tbsp	3
01072	Dessert topping, pressurized	4	1 tbsp	1
01073	Dessert topping, semi solid, frozen	4	1 tbsp	0
02045	Dill weed, fresh	1	5 sprigs	1
18248	Doughnuts, cake-type, plain (includes unsugared, old-fashioned)	47	1 medium	123
18248	Doughnuts, cake-type, plain (includes unsugared, old-fashioned)	14	1 hole	37
18255	Doughnuts, yeast-leavened, glazed, enriched (includes honey buns)	60	1 medium	83
18255	Doughnuts, yeast-leavened, glazed, enriched (includes honey buns)	13	1 hole	18
05142	Duck, domesticated, meat only, cooked, roasted	221	1/2 duck	449
18257	Eclairs, custard-filled with chocolate glaze, prepared from recipe	100	1 eclair	107
01143	Egg substitute, liquid	62.75	1/4 cup	76
01124	Egg, white, raw, fresh	33.4	1 large	5
01128	Egg, whole, cooked, fried	46	1 large	96
01129	Egg, whole, cooked, hard-boiled	50	1 large	86
01131	Egg, whole, cooked, poached	50	1 large	95
01132	Egg, whole, cooked, scrambled	61	1 large	104

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
01123	Egg, whole, raw, fresh	50	1 large	96
01123	Egg, whole, raw, fresh	44	1 medium	84
01123	Egg, whole, raw, fresh	58	1 extra large	111
01125	Egg, yolk, raw, fresh	16.6	1 large	65
01057	Eggnog	254	1 cup	277
11210	Eggplant, cooked, boiled, drained, without salt	99	1 cup	15
11213	Endive, raw	50	1 cup	14
18258	English muffins, plain, enriched, with ca prop (includes sourdough)	57	1 muffin	52
18259	English muffins, plain, toasted, enriched, with calcium propionate (includes sourdough)	52	1 muffin	56
21047	Entrees, fish fillet, battered or breaded, and fried	91	1 fillet	156
21302	Fast Food, Pizza Chain, 14" pizza, pepperoni topping, regular crust	106	1 slice	212
21005	Fast Foods, biscuit, with egg and sausage	180	1 biscuit	562
21061	Fast foods, burrito, with beans and cheese	93	1 burrito	90
21063	Fast foods, burrito, with beans and meat	115.5	1 burrito	70
21094	Fast foods, cheeseburger, regular, double patty and bun, plain	160	1 sandwich	254
21093	Fast foods, cheeseburger; double, regular patty, with condiments and vegetables	166	1 sandwich	242
21092	Fast foods, cheeseburger; double, regular patty; plain	155	1 sandwich	284
21097	Fast foods, cheeseburger; single, large patty; with condiments and bacon	195	1 sandwich	353
21098	Fast foods, cheeseburger; single, large patty; with condiments and vegetables	219	1 sandwich	261
21090	Fast foods, cheeseburger; single, regular patty, with condiments	113	1 sandwich	160
21089	Fast foods, cheeseburger; single, regular patty; plain	102	1 sandwich	162
21102	Fast foods, chicken fillet sandwich, plain	182	1 sandwich	233
21229	Fast foods, chicken, breaded and fried, boneless pieces, plain	106	6 pieces	306
21042	Fast foods, chili con carne	253	1 cup	197
21070	Fast foods, chimichanga, with beef	174	1 chimichanga	124
21043	Fast foods, clams, breaded and fried	115	3/4 cup	238
21127	Fast foods, coleslaw	99	3/4 cup	36
21012	Fast foods, croissant, with egg, cheese, and bacon	129	1 croissant	276
21015	Fast foods, danish pastry, cheese	91	1 pastry	80
21017	Fast foods, danish pastry, fruit	94	1 pastry	69
21074	Fast foods, enchilada, with cheese	163	1 enchilada	134
21021	Fast foods, english muffin, with egg, cheese, and canadian bacon	137	1 muffin	269
21106	Fast foods, fish sandwich, with tartar sauce and cheese	183	1 sandwich	311
21024	Fast foods, french toast sticks	141	5 sticks	123
21023	Fast foods, french toast with butter	135	2 slices	146
21077	Fast foods, frijoles with cheese	167	1 cup	175
21114	Fast foods, hamburger; double, large patty; with condiments and vegetables	226	1 sandwich	314
21111	Fast foods, hamburger; double, regular patty; with condiments	215	1 sandwich	284
21113	Fast foods, hamburger; single, large patty; with condiments and vegetables	218	1 sandwich	233
21108	Fast foods, hamburger; single, regular patty; with condiments	106	1 sandwich	118
21118	Fast foods, hotdog, plain	98	1 sandwich	97
21119	Fast foods, hotdog, with chili	114	1 sandwich	192
21120	Fast foods, hotdog, with corn flour coating (corndog)	175	1 corn dog	166
21129	Fast foods, hush puppies	78	5 pieces	190
21028	Fast foods, ice milk, vanilla, soft-serve, with cone	103	1 cone	139

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
21078	Fast foods, nachos, with cheese	113	6-8 nachos	276
21130	Fast foods, onion rings, breaded and fried	83	8-9 rings	86
21025	Fast foods, pancakes with butter and syrup	232	2 pancakes	476
21138	Fast foods, potato, french fried in vegetable oil	169	1 large	233
21138	Fast foods, potato, french fried in vegetable oil	134	1 medium	185
21138	Fast foods, potato, french fried in vegetable oil	85	1 small	117
21139	Fast foods, potato, mashed	80	1/3 cup	44
21026	Fast foods, potatoes, hashed brown	72	1/2 cup	79
21121	Fast foods, roast beef sandwich, plain	139	1 sandwich	239
21053	Fast foods, salad, vegetable, tossed, without dressing, with cheese and egg	217	1-1/2 cups	132
21054	Fast foods, salad, vegetable, tossed, without dressing, with chicken	218	1-1/2 cups	170
21059	Fast foods, shrimp, breaded and fried	164	6-8 shrimp	344
21124	Fast foods, submarine sandwich, with cold cuts	228	1 sandwich, 6" roll	287
21125	Fast foods, submarine sandwich, with roast beef	216	1 sandwich, 6" roll	192
21126	Fast foods, submarine sandwich, with tuna salad	256	1 sandwich, 6" roll	220
21033	Fast foods, sundae, hot fudge	158	1 sundae	228
21082	Fast foods, taco	171	1 small	203
21082	Fast foods, taco	263	1 large	313
21083	Fast foods, taco salad	198	1-1/2 cups	143
21086	Fast foods, tostada, with beans, beef, and cheese	225	1 tostada	173
09094	Figs, dried, uncooked	38	2 figs	25
15011	Fish, catfish, channel, cooked, breaded and fried	85	3 oz	184
15017	Fish, cod, Atlantic, canned, solids and liquid	85	3 oz	221
15192	Fish, cod, Pacific, cooked, dry heat	85	3 oz	190
15027	Fish, fish portions and sticks, frozen, preheated	57	1 portion (4" x 2" x 1/2")	104
15027	Fish, fish portions and sticks, frozen, preheated	28	1 stick (4" x 1" x 1/2")	51
15029	Fish, flatfish (flounder and sole species), cooked, dry heat	85	3 oz	246
15029	Fish, flatfish (flounder and sole species), cooked, dry heat	127	1 fillet	367
15034	Fish, haddock, cooked, dry heat	85	3 oz	205
15034	Fish, haddock, cooked, dry heat	150	1 fillet	362
15037	Fish, halibut, Atlantic and Pacific, cooked, dry heat	85	3 oz	242
15037	Fish, halibut, Atlantic and Pacific, cooked, dry heat	159	1/2 fillet	453
15041	Fish, herring, Atlantic, pickled	85.05	3 oz	76
15058	Fish, ocean perch, Atlantic, cooked, dry heat	85	3 oz	235
15058	Fish, ocean perch, Atlantic, cooked, dry heat	50	1 fillet	139
15067	Fish, pollock, walleye, cooked, dry heat	60	1 fillet	289
15067	Fish, pollock, walleye, cooked, dry heat	85	3 oz	410
15071	Fish, rockfish, Pacific, mixed species, cooked, dry heat	149	1 fillet	340
15071	Fish, rockfish, Pacific, mixed species, cooked, dry heat	85	3 oz	194
15232	Fish, roughy, orange, cooked, dry heat	85	3 oz	87
15077	Fish, salmon, chinook, smoked	85.05	3 oz	139
15084	Fish, salmon, pink, canned, solids with bone and liquid	85	3 oz	280
15086	Fish, salmon, sockeye, cooked, dry heat	155	1/2 fillet	428
15086	Fish, salmon, sockeye, cooked, dry heat	85	3 oz	235
15088	Fish, sardine, Atlantic, canned in oil, drained solids with bone	85.05	3 oz	417
15111	Fish, swordfish, cooked, dry heat	106	1 piece	357
15111	Fish, swordfish, cooked, dry heat	85	3 oz	286
15241	Fish, trout, rainbow, farmed, cooked, dry heat	85	3 oz	226

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
15128	Fish, tuna salad	205	1 cup	365
15119	Fish, tuna, light, canned in oil, drained solids	85.05	3 oz	265
15121	Fish, tuna, light, canned in water, drained solids	85	3 oz	139
15126	Fish, tuna, white, canned in water, drained solids	85	3 oz	184
15221	Fish, tuna, yellowfin, fresh, cooked, dry heat	85	3 oz	208
07022	Frankfurter, beef	45	1 frank	72
07023	Frankfurter, beef and pork	45	1 frank	39
07024	Frankfurter, chicken	45	1 frank	73
18268	French toast, frozen, ready-to-heat	59	1 slice	82
18269	French toast, prepared from recipe, made with low fat (2%) milk	65	1 slice	76
19226	Frostings, chocolate, creamy, ready-to-eat	38	1/12 package	30
19230	Frostings, vanilla, creamy, ready-to-eat	38	1/12 package	7
19263	Frozen novelties, fruit and juice bars	77	1 bar (2.5 fl oz)	5
19281	Frozen novelties, ice type, italian, restaurant-prepared	116	1/2 cup	0
19283	Frozen novelties, ice type, pop	59	1 bar (2 fl oz)	0
19393	Frozen yogurts, chocolate, soft-serve	72	1/2 cup	100
19293	Frozen yogurts, vanilla, soft-serve	72	1/2 cup	93
19294	Fruit butters, apple	17	1 tbsp	1
09100	Fruit cocktail, (peach and pineapple and pear and grape and cherry), canned, heavy syrup, solids and liquids	248	1 cup	27
09097	Fruit cocktail, (peach and pineapple and pear and grape and cherry), canned, juice pack, solids and liquids	237	1 cup	33
14267	Fruit punch drink, with added nutrients, canned	248	8 fl oz	7
09189	Fruit, mixed, (peach and cherry-sweet and -sour and raspberry and grape and boysenberry), frozen, sweetened	250	1 cup	30
35142	Frybread, made with lard (Navajo)	160	10-1/2" bread	197
35142	Frybread, made with lard (Navajo)	90	5" bread	111
11215	Garlic, raw	3	1 clove	5
19173	Gelatin desserts, dry mix, prepared with water	135	1/2 cup	30
19176	Gelatin desserts, dry mix, reduced calorie, with aspartame, prepared with water	117	1/2 cup	80
14277	Grape drink, canned	250	8 fl oz	0
09137	Grape juice cocktail, frozen concentrate, diluted with 3 volume water, with added ascorbic acid	250	1 cup	10
09136	Grape juice cocktail, frozen concentrate, undiluted, with added ascorbic acid	216	6-fl-oz can	32
09135	Grape juice, canned or bottled, unsweetened, without added ascorbic acid	253	1 cup	35
09404	Grapefruit juice, pink, raw	247	1 cup	37
09124	Grapefruit juice, white, canned, sweetened	250	1 cup	28
09123	Grapefruit juice, white, canned, unsweetened	247	1 cup	27
09126	Grapefruit juice, white, frozen concentrate, unsweetened, diluted with 3 volume water	247	1 cup	35
09125	Grapefruit juice, white, frozen concentrate, unsweetened, undiluted	207	6-fl-oz can	101
09128	Grapefruit juice, white, raw	247	1 cup	37
09112	Grapefruit, raw, pink and red, all areas	123	1/2 grapefruit	22
09116	Grapefruit, raw, white, all areas	118	1/2 grapefruit	9
09121	Grapefruit, sections, canned, light syrup pack, solids and liquids	254	1 cup	25
09132	Grapes, red or green (European type, such as Thompson seedless), raw	160	1 cup	32
09132	Grapes, red or green (European type, such as Thompson seedless), raw	50	10 grapes	10
06116	Gravy, beef, canned, ready-to-serve	58.25	1/4 cup	17
06119	Gravy, chicken, canned, ready-to-serve	59.5	1/4 cup	17

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
06121	Gravy, mushroom, canned	59.6	1/4 cup	9
06125	Gravy, turkey, canned, ready-to-serve	59.6	1/4 cup	17
07027	Ham, chopped, not canned	21	2 slices	33
07028	Ham, sliced, extra lean	56.7	2 slices	163
07029	Ham, sliced, regular (approximately 11% fat)	56.7	2 slices	87
11961	Hearts of palm, canned	33	1 piece	21
19296	Honey	21	1 tbsp	1
02055	Horseradish, prepared	5	1 tsp	2
16158	Hummus, commercial	14	1 tbsp	25
19270	Ice creams, chocolate	66	1/2 cup	71
19090	Ice creams, french vanilla, soft-serve	86	1/2 cup	100
19095	Ice creams, vanilla	66	1/2 cup	69
19088	Ice creams, vanilla, light	66	1/2 cup	68
19089	Ice creams, vanilla, rich	74	1/2 cup	78
19297	Jams and preserves	20	1 tbsp	4
19300	Jellies	19	1 tbsp	1
11226	Jerusalem-artichokes, raw	150	1 cup	117
11234	Kale, cooked, boiled, drained, without salt	130	1 cup	36
11236	Kale, frozen, cooked, boiled, drained, without salt	130	1 cup	36
18505	KELLOGG'S Eggo Lowfat Homestyle Waffles	35	1 waffle	28
09148	Kiwi fruit, (chinese gooseberries), fresh, raw	76	1 medium	26
11242	Kohlrabi, cooked, boiled, drained, without salt	165	1 cup	74
17012	Lamb, domestic, leg, whole (shank and sirloin), separable lean and fat, trimmed to 1/4" fat, choice, cooked, roasted	85	3 oz	162
17014	Lamb, domestic, leg, whole (shank and sirloin), separable lean only, trimmed to 1/4" fat, choice, cooked, roasted	85	3 oz	175
17024	Lamb, domestic, loin, separable lean and fat, trimmed to 1/4" fat, choice, cooked, broiled	85	3 oz	167
17027	Lamb, domestic, loin, separable lean only, trimmed to 1/4" fat, choice, cooked, broiled	85	3 oz	192
17031	Lamb, domestic, rib, separable lean and fat, trimmed to 1/4" fat, choice, cooked, roasted	85	3 oz	141
17034	Lamb, domestic, rib, separable lean only, trimmed to 1/4" fat, choice, cooked, roasted	85	3 oz	166
17044	Lamb, domestic, shoulder, arm, separable lean and fat, trimmed to 1/4" fat, choice, cooked, braised	85	3 oz	175
17048	Lamb, domestic, shoulder, arm, separable lean only, trimmed to 1/4" fat, choice, cooked, braised	85	3 oz	197
04002	Lard	12.8	1 tbsp	0
18369	Leavening agents, baking powder, double-acting, sodium aluminum sulfate	4.6	1 tsp	101
18370	Leavening agents, baking powder, double-acting, straight phosphate	4.6	1 tsp	456
18371	Leavening agents, baking powder, low-sodium	5	1 tsp	343
18372	Leavening agents, baking soda	4.6	1 tsp	0
18373	Leavening agents, cream of tartar	3	1 tsp	0
18375	Leavening agents, yeast, baker's, active dry	7	1 pkg	90
18375	Leavening agents, yeast, baker's, active dry	4	1 tsp	52
18374	Leavening agents, yeast, baker's, compressed	17	1 cake	57
11247	Leeks, (bulb and lower leaf-portion), cooked, boiled, drained, without salt	104	1 cup	18
09153	Lemon juice, canned or bottled	15.2	1 tbsp	1
09153	Lemon juice, canned or bottled	244	1 cup	22
09152	Lemon juice, raw	47	juice of 1 lemon	3

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
14293	Lemonade, frozen concentrate, white, prepared with water	248	8 fl oz	5
14290	Lemonade, low calorie, with aspartame, powder, prepared with water	237	8 fl oz	31
14297	Lemonade-flavor drink, powder, prepared with water	266	8 fl oz	3
09150	Lemons, raw, without peel	58	1 lemon	9
16070	Lentils, mature seeds, cooked, boiled, without salt	198	1 cup	356
11250	Lettuce, butterhead (includes boston and bibb types), raw	163	1 head	54
11250	Lettuce, butterhead (includes boston and bibb types), raw	7.5	1 medium leaf	2
11251	Lettuce, cos or romaine, raw	56	1 cup	17
11251	Lettuce, cos or romaine, raw	10	1 leaf	3
11253	Lettuce, green leaf, raw	56	1 cup	16
11253	Lettuce, green leaf, raw	10	1 leaf	3
11252	Lettuce, iceberg (includes crisphead types), raw	8	1 medium	2
11252	Lettuce, iceberg (includes crisphead types), raw	55	1 cup	11
11252	Lettuce, iceberg (includes crisphead types), raw	539	1 head	108
11040	Lima beans, immature seeds, frozen, baby, cooked, boiled, drained, without salt	180	1 cup	202
11038	Lima beans, immature seeds, frozen, fordhook, cooked, boiled, drained, without salt	170	1 cup	165
16073	Lima beans, large, mature seeds, canned	241	1 cup	178
16072	Lima beans, large, mature seeds, cooked, boiled, without salt	188	1 cup	209
09161	Lime juice, canned or bottled, unsweetened	15.4	1 tbs	2
09161	Lime juice, canned or bottled, unsweetened	246	1 cup	25
09160	Lime juice, raw	38	juice of 1 lime	5
22247	Macaroni and Cheese, canned entree	252	1 cup	118
20100	Macaroni, cooked, enriched	140	1 cup	81
14315	Malted drink mix, chocolate, with added nutrients, powder	21	3 heaping tsp	84
14316	Malted drink mix, chocolate, with added nutrients, powder, prepared with whole milk	265	1 cup	289
14309	Malted drink mix, natural, with added nutrients, powder	21	4-5 heaping tsp	79
14310	Malted drink mix, natural, with added nutrients, powder, prepared with whole milk	265	1 cup	284
09176	Mangos, raw	207	1 mango	23
09176	Mangos, raw	165	1 cup	18
04613	Margarine, margarine-like vegetable oil spread, 60% fat, tub	4.8	1 tsp	1
04611	Margarine, regular, tub, composite, 80% fat, with salt	14.2	1 tbs	1
04132	Margarine, regular, unspecified oils, with salt added	14.1	1 tbs	3
04612	Margarine, vegetable oil spread, 60% fat, stick	14.3	1 tbs	2
04612	Margarine, vegetable oil spread, 60% fat, stick	4.8	1 tsp	1
04585	Margarine-butter blend, soybean oil and butter	14.2	1 tbs	1
04128	Margarine-like spread, (approximately 37% fat), unspecified oils	4.8	1 tsp	0
09181	Melons, cantaloupe, raw	69	1/8 melon	10
09181	Melons, cantaloupe, raw	160	1 cup	24
09184	Melons, honeydew, raw	160	1/8 melon	18
09184	Melons, honeydew, raw	170	1 cup	19
01110	Milk shakes, thick chocolate	300	10.6 fl oz	378
01111	Milk shakes, thick vanilla	313	11 fl oz	360
01094	Milk, buttermilk, dried	6.5	1 tbs	61
01088	Milk, buttermilk, fluid, cultured, lowfat	245	1 cup	218
01095	Milk, canned, condensed, sweetened	306	1 cup	774
01097	Milk, canned, evaporated, nonfat	256	1 cup	499

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
01096	Milk, canned, evaporated, without added vitamin A	252	1 cup	512
01104	Milk, chocolate, fluid, commercial, lowfat	250	1 cup	258
01103	Milk, chocolate, fluid, commercial, reduced fat	250	1 cup	255
01102	Milk, chocolate, fluid, commercial, whole	250	1 cup	253
01092	Milk, dry, nonfat, instant, with added vitamin A	23	1/3 cup	227
01082	Milk, lowfat, fluid, 1% milkfat, with added vitamin A	244	1 cup	232
01085	Milk, nonfat, fluid, with added vitamin A (fat free or skim)	245	1 cup	247
01079	Milk, reduced fat, fluid, 2% milkfat, with added vitamin A	244	1 cup	229
01077	Milk, whole, 3.25% milkfat	244	1 cup	222
16112	Miso	68.75	1 cup	109
15160	Mollusks, clam, mixed species, canned, drained solids	85	3 oz	287
15157	Mollusks, clam, mixed species, raw	85	3 oz	144
15168	Mollusks, oyster, eastern, cooked, breaded and fried	85	3 oz	135
15167	Mollusks, oyster, eastern, wild, raw	84	6 medium	113
15173	Mollusks, scallop, mixed species, cooked, breaded and fried	93	6 large	219
22120	MORNINGSTAR FARMS Grillers Recipe Crumbles, frozen, unprepared	110	1 cup	221
22121	MORNINGSTAR FARMS Grillers Vegan, frozen, unprepared	85	1 patty	188
18274	Muffins, blueberry, commercially prepared (Includes mini-muffins)	57	1 muffin	71
18278	Muffins, blueberry, prepared from recipe, made with low fat (2%) milk	57	1 muffin	83
18279	Muffins, corn, commercially prepared	57	1 muffin	162
18280	Muffins, corn, dry mix, prepared	50	1 muffin	192
18283	Muffins, oat bran	57	1 muffin	214
18388	Muffins, wheat bran, toaster-type with raisins, toasted	34	1 muffin	97
11044	Mung beans, mature seeds, sprouted, cooked, boiled, drained, without salt	124	1 cup	35
11043	Mung beans, mature seeds, sprouted, raw	104	1 cup	56
11264	Mushrooms, canned, drained solids	156	1 cup	103
11261	Mushrooms, cooked, boiled, drained, without salt	156	1 cup	136
11269	Mushrooms, shiitake, cooked, without salt	145	1 cup	42
11268	Mushrooms, shiitake, dried	3.6	1 mushroom	11
11260	Mushrooms, white, raw	70	1 cup	60
11271	Mustard greens, cooked, boiled, drained, without salt	140	1 cup	57
02046	Mustard, prepared, yellow	5	1 tsp or 1 packet	5
18651	NABISCO, NABISCO SNACKWELL'S Fat Free Devil's Food Cookie Cakes	16	1 cookie	11
09191	Nectarines, raw	136	1 nectarine	35
20113	Noodles, chinese, chow mein	45	1 cup	72
20110	Noodles, egg, cooked, enriched	160	1 cup	122
20112	Noodles, egg, spinach, cooked, enriched	160	1 cup	91
12061	Nuts, almonds	28.35	1 oz (24 nuts)	137
12078	Nuts, brazilnuts, dried, unblanched	28.35	1 oz (6-8 nuts)	206
12585	Nuts, cashew nuts, dry roasted, with salt added	28.35	1 oz	139
12586	Nuts, cashew nuts, oil roasted, with salt added	28.35	1 oz (18 nuts)	151
12167	Nuts, chestnuts, european, roasted	143	1 cup	153
12179	Nuts, coconut meat, dried (desiccated), sweetened, shredded	93	1 cup	100
12104	Nuts, coconut meat, raw	45	1 piece	51
12120	Nuts, hazelnuts or filberts	28.35	1 oz	82
12632	Nuts, macadamia nuts, dry roasted, with salt added	28.35	1 oz (10-12 nuts)	56

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
12635	Nuts, mixed nuts, dry roasted, with peanuts, with salt added	28.35	1 oz	123
12637	Nuts, mixed nuts, with peanuts, oil roasted, with salt added	28.35	1 oz	132
12142	Nuts, pecans	28.35	1 oz (20 halves)	79
12147	Nuts, pine nuts, dried	8.6	1 tbsp	49
12147	Nuts, pine nuts, dried	28.35	1 oz	163
12652	Nuts, pistachio nuts, dry roasted, with salt added	28.35	1 oz (47 nuts)	137
12155	Nuts, walnuts, english	28.35	1 oz (14 halves)	98
20034	Oat bran, cooked	219	1 cup	261
20033	Oat bran, raw	94	1 cup	690
04053	Oil, olive, salad or cooking	13.5	1 tbsp	0
04042	Oil, peanut, salad or cooking	13.5	1 tbsp	0
04058	Oil, sesame, salad or cooking	13.6	1 tbsp	0
04543	Oil, soybean, salad or cooking, (hydrogenated) and cottonseed	13.6	1 tbsp	0
04034	Oil, soybean, salad or cooking, (partially hydrogenated)	13.6	1 tbsp	0
04511	Oil, vegetable safflower, salad or cooking, oleic, over 70% (primary safflower oil of commerce)	13.6	1 tbsp	0
04582	Oil, vegetable, canola	14	1 tbsp	0
04518	Oil, vegetable, corn, industrial and retail, all purpose salad or cooking	13.6	1 tbsp	0
04506	Oil, vegetable, sunflower, linoleic, (approx. 65%)	13.6	1 tbsp	0
11279	Okra, cooked, boiled, drained, without salt	160	1 cup	51
11281	Okra, frozen, cooked, boiled, drained, without salt	184	1 cup	85
09193	Olives, ripe, canned (small-extra large)	22	5 large	1
11296	Onion rings, breaded, par fried, frozen, prepared, heated in oven	60	10 rings	49
11283	Onions, cooked, boiled, drained, without salt	94	1 medium	33
11283	Onions, cooked, boiled, drained, without salt	210	1 cup	74
11284	Onions, dehydrated flakes	5	1 tbsp	15
11282	Onions, raw	160	1 cup	46
11282	Onions, raw	14	1 slice	4
11282	Onions, raw	110	1 whole	32
11291	Onions, spring or scallions (includes tops and bulb), raw	15	1 whole	6
11291	Onions, spring or scallions (includes tops and bulb), raw	100	1 cup	37
09207	Orange juice, canned, unsweetened	249	1 cup	42
09209	Orange juice, chilled, includes from concentrate	249	1 cup	27
09215	Orange juice, frozen concentrate, unsweetened, diluted with 3 volume water	249	1 cup	40
09214	Orange juice, frozen concentrate, unsweetened, undiluted	213	6-fl-oz can	121
09206	Orange juice, raw	86	juice from 1 orange	15
09206	Orange juice, raw	248	1 cup	42
09200	Oranges, raw, all commercial varieties	131	1 orange	18
09200	Oranges, raw, all commercial varieties	180	1 cup	25
18288	Pancakes plain, frozen, ready-to-heat (includes buttermilk)	36	1 pancake	105
18290	Pancakes, plain, dry mix, complete, prepared	38	1 pancake	127
18292	Pancakes, plain, dry mix, incomplete, prepared	38	1 pancake	119
09226	Papayas, raw	304	1 papaya	15
09226	Papayas, raw	140	1 cup	7
11297	Parsley, raw	10	10 sprigs	6
11299	Parsnips, cooked, boiled, drained, without salt	156	1 cup	108
22907	Pasta with meatballs in tomato sauce, canned entree	252	1 cup	116
09241	Peaches, canned, heavy syrup pack, solids and liquids	98	1 half	11

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
09241	Peaches, canned, heavy syrup pack, solids and liquids	262	1 cup	29
09238	Peaches, canned, juice pack, solids and liquids	248	1 cup	42
09238	Peaches, canned, juice pack, solids and liquids	98	1 half	17
09246	Peaches, dried, sulfured, uncooked	39	3 halves	46
09250	Peaches, frozen, sliced, sweetened	250	1 cup	28
09236	Peaches, raw	170	1 cup	34
09236	Peaches, raw	98	1 peach	20
16097	Peanut butter, chunk style, with salt	16	1 tbsp	51
16098	Peanut butter, smooth style, with salt	16	1 tbsp	57
16090	Peanuts, all types, dry-roasted, with salt	28.35	1 oz (approx 28)	101
16390	Peanuts, all types, dry-roasted, without salt	28.35	1 oz (approx 28)	101
16089	Peanuts, all types, oil-roasted, with salt	28.35	1 oz	113
09340	Pears, asian, raw	122	1 pear	13
09340	Pears, asian, raw	275	1 pear	30
09257	Pears, canned, heavy syrup pack, solids and liquids	76	1 half	5
09257	Pears, canned, heavy syrup pack, solids and liquids	266	1 cup	19
09254	Pears, canned, juice pack, solids and liquids	248	1 cup	30
09254	Pears, canned, juice pack, solids and liquids	76	1 half	9
09252	Pears, raw	166	1 pear	18
11301	Peas, edible-podded, boiled, drained, without salt	160	1 cup	88
11303	Peas, edible-podded, frozen, cooked, boiled, drained, without salt	160	1 cup	93
11308	Peas, green (includes baby and lesuer types), canned, drained soilds, unprepared	170	1 cup	117
11313	Peas, green, frozen, cooked, boiled, drained, without salt	160	1 cup	123
16086	Peas, split, mature seeds, cooked, boiled, without salt	196	1 cup	194
11670	Peppers, hot chili, green, raw	45	1 pepper	21
11819	Peppers, hot chili, red, raw	45	1 pepper	19
11632	Peppers, jalapeno, canned, solids and liquids	26	1/4 cup	5
11334	Peppers, sweet, green, cooked, boiled, drained, without salt	136	1 cup	24
11333	Peppers, sweet, green, raw	149	1 cup	30
11333	Peppers, sweet, green, raw	10	1 ring	2
11333	Peppers, sweet, green, raw	119	1 pepper	24
11823	Peppers, sweet, red, cooked, boiled, drained, without salt	136	1 cup	24
11821	Peppers, sweet, red, raw	149	1 cup	39
11821	Peppers, sweet, red, raw	119	1 pepper	31
11945	Pickle relish, sweet	15	1 tbsp	2
11937	Pickles, cucumber, dill or kosher dill	65	1 pickle	8
18330	Pie crust, cookie-type, prepared from recipe, graham cracker, baked	239	1 pie shell	155
18335	Pie crust, standard-type, frozen, ready-to-bake, enriched, baked	126	1 pie shell	103
18336	Pie crust, standard-type, prepared from recipe, baked	180	1 pie shell	121
19312	Pie fillings, apple, canned	74	1/8 of 21-oz can	5
19314	Pie fillings, canned, cherry	74	1/8 of 21-oz can	11
18301	Pie, apple, commercially prepared, enriched flour	117	1 piece	28
18302	Pie, apple, prepared from recipe	155	1 piece	43
18305	Pie, blueberry, commercially prepared	117	1 piece	27
18306	Pie, blueberry, prepared from recipe	147	1 piece	44
18308	Pie, cherry, commercially prepared	117	1 piece	34
18309	Pie, cherry, prepared from recipe	180	1 piece	54
18310	Pie, chocolate creme, commercially prepared	113	1 piece	77

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
18316	Pie, coconut custard, commercially prepared	104	1 piece	127
18444	Pie, fried pies, cherry	128	1 pie	55
18319	Pie, fried pies, fruit	128	1 pie	55
18320	Pie, lemon meringue, commercially prepared	113	1 piece	119
18321	Pie, lemon meringue, prepared from recipe	127	1 piece	53
18324	Pie, pecan, commercially prepared	113	1 piece	94
18325	Pie, pecan, prepared from recipe	122	1 piece	115
18326	Pie, pumpkin, commercially prepared	109	1 piece	88
18327	Pie, pumpkin, prepared from recipe	155	1 piece	152
11943	Pimento, canned	12	1 tbsp	2
14334	Pineapple and grapefruit juice drink, canned	250	8 fl oz	15
14341	Pineapple and orange juice drink, canned	250	8 fl oz	10
09273	Pineapple juice, canned, unsweetened, without added ascorbic acid	250	1 cup	20
09270	Pineapple, canned, heavy syrup pack, solids and liquids	254	1 cup	18
09270	Pineapple, canned, heavy syrup pack, solids and liquids	49	1 slice	3
09268	Pineapple, canned, juice pack, solids and liquids	47	1 slice	3
09268	Pineapple, canned, juice pack, solids and liquids	249	1 cup	15
09266	Pineapple, raw, all varieties	155	1 cup	12
21224	Pizza, cheese topping, regular crust, frozen, cooked	63	1 serving	113
21226	Pizza, meat and vegetable topping, regular crust, frozen, cooked	79	1 serving	143
09278	Plantains, cooked	154	1 cup	43
09277	Plantains, raw	179	1 medium	61
09284	Plums, canned, purple, heavy syrup pack, solids and liquids	258	1 cup	34
09284	Plums, canned, purple, heavy syrup pack, solids and liquids	46	1 plum	6
09282	Plums, canned, purple, juice pack, solids and liquids	46	1 plum	7
09282	Plums, canned, purple, juice pack, solids and liquids	252	1 cup	38
09292	Plums, dried (prunes), stewed, without added sugar	248	1 cup	74
09291	Plums, dried (prunes), uncooked	42	5 prunes	29
09279	Plums, raw	66	1 plum	11
07065	Pork and beef sausage, fresh, cooked	26	2 links	28
07064	Pork sausage, fresh, cooked	27	1 patty	44
07064	Pork sausage, fresh, cooked	26	2 links	42
10124	Pork, cured, bacon, cooked, broiled, pan-fried or roasted	19	3 medium slices	101
10131	Pork, cured, canadian-style bacon, grilled	46.5	2 slices	138
10185	Pork, cured, ham, extra lean and regular, canned, roasted	85	3 oz	188
10151	Pork, cured, ham, whole, separable lean and fat, roasted	85	3 oz	182
10153	Pork, cured, ham, whole, separable lean only, roasted	85	3 oz	193
10193	Pork, fresh, backribs, separable lean and fat, cooked, roasted	85	3 oz	166
10009	Pork, fresh, leg (ham), whole, separable lean and fat, cooked, roasted	85	3 oz	224
10011	Pork, fresh, leg (ham), whole, separable lean only, cooked, roasted	85	3 oz	239
10038	Pork, fresh, loin, center loin (chops), bone-in, separable lean and fat, cooked, broiled	85	3 oz	187
10179	Pork, fresh, loin, center loin (chops), bone-in, separable lean and fat, cooked, pan-fried	85	3 oz	220
10042	Pork, fresh, loin, center loin (chops), bone-in, separable lean only, cooked, broiled	85	3 oz	194
10176	Pork, fresh, loin, center loin (chops), bone-in, separable lean only, cooked, pan-fried	85	3 oz	230
10047	Pork, fresh, loin, center rib (roasts), bone-in, separable lean and fat, cooked, roasted	85	3 oz	196

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
10051	Pork, fresh, loin, center rib (roasts), bone-in, separable lean only, cooked, roasted	85	3 oz	201
10205	Pork, fresh, loin, country-style ribs, separable lean and fat, cooked, braised	85	3 oz	172
10075	Pork, fresh, shoulder, arm picnic, separable lean and fat, cooked, braised	85	3 oz	180
10078	Pork, fresh, shoulder, arm picnic, separable lean only, cooked, braised	85	3 oz	192
10089	Pork, fresh, spareribs, separable lean and fat, cooked, braised	85	3 oz	222
11672	Potato pancakes	76	1 pancake	97
11399	Potato puffs, frozen, oven-heated	79	10 puffs	81
11414	Potato salad, home-prepared	250	1 cup	130
11674	Potato, baked, flesh and skin, without salt	202	1 potato	141
11385	Potatoes, au gratin, dry mix, prepared with water, whole milk and butter	245	1 cup	233
11373	Potatoes, au gratin, home-prepared from recipe using butter	245	1 cup	277
11363	Potatoes, baked, flesh, without salt	156	1 potato	78
11364	Potatoes, baked, skin, without salt	58	1 skin	59
11365	Potatoes, boiled, cooked in skin, flesh, without salt	136	1 potato	60
11367	Potatoes, boiled, cooked without skin, flesh, without salt	135	1 potato	54
11367	Potatoes, boiled, cooked without skin, flesh, without salt	156	1 cup	62
11403	Potatoes, french fried, all types, salt added in processing, frozen, home-prepared, oven heated	50	10 strips	49
11391	Potatoes, hashed brown, frozen, plain, prepared	29	1 patty	21
11370	Potatoes, hashed brown, home-prepared	156	1 cup	109
11379	Potatoes, mashed, dehydrated, prepared from flakes without milk, whole milk and butter added	210	1 cup	86
11657	Potatoes, mashed, home-prepared, whole milk added	210	1 cup	99
11371	Potatoes, mashed, home-prepared, whole milk and margarine added	210	1 cup	103
11387	Potatoes, scalloped, dry mix, prepared with water, whole milk and butter	245	1 cup	137
11372	Potatoes, scalloped, home-prepared with butter	245	1 cup	154
05306	Poultry food products, ground turkey, cooked	82	1 patty	161
09294	Prune juice, canned	256	1 cup	64
19123	Puddings, chocolate, dry mix, instant, prepared with 2% milk	147	1/2 cup	350
19190	Puddings, chocolate, dry mix, regular, prepared with 2% milk	142	1/2 cup	136
19183	Puddings, chocolate, ready-to-eat	113	4 oz	63
19193	Puddings, rice, ready-to-eat	113.4	4 oz	77
19218	Puddings, tapioca, ready-to-eat	113	4 oz	68
19212	Puddings, vanilla, dry mix, regular, prepared with 2% milk	140	1/2 cup	116
19201	Puddings, vanilla, ready-to-eat	113	4 oz	46
11424	Pumpkin, canned, without salt	245	1 cup	86
11423	Pumpkin, cooked, boiled, drained, without salt	245	1 cup	74
11429	Radishes, raw	4.5	1 radish	1
09298	Raisins, seedless	14	1 packet	14
09298	Raisins, seedless	145	1 cup	146
09306	Raspberries, frozen, red, sweetened	250	1 cup	43
09302	Raspberries, raw	123	1 cup	36
16103	Refried beans, canned, traditional style (includes USDA commodity)	252	1 cup	280
09310	Rhubarb, frozen, cooked, with sugar	240	1 cup	19
20037	Rice, brown, long-grain, cooked	195	1 cup	162
20047	Rice, white, long-grain, parboiled, enriched, cooked	175	1 cup	96

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NDB_No	Description	Weight (g)	Common Measure	Content per Measure
20046	Rice, white, long-grain, parboiled, enriched, dry	185	1 cup	289
20049	Rice, white, long-grain, precooked or instant, enriched, prepared	165	1 cup	61
20045	Rice, white, long-grain, regular, cooked	158	1 cup	68
20044	Rice, white, long-grain, regular, raw, enriched	185	1 cup	213
18342	Rolls, dinner, plain, commercially prepared (includes brown-and-serve)	28	1 roll	34
18350	Rolls, hamburger or hotdog, plain	43	1 roll	27
18353	Rolls, hard (includes kaiser)	57	1 roll	57
11436	Rutabagas, cooked, boiled, drained, without salt	170	1 cup	95
04539	Salad dressing, blue or roquefort cheese dressing, commercial, regular	15.3	1 tbsp	11
04120	Salad dressing, french dressing, commercial, regular	15.6	1 tbsp	3
04020	Salad dressing, french dressing, reduced fat	16.3	1 tbsp	3
04133	Salad dressing, french, home recipe	14	1 tbsp	0
04134	Salad dressing, home recipe, cooked	16	1 tbsp	14
04135	Salad dressing, home recipe, vinegar and oil	15.6	1 tbsp	0
04114	Salad dressing, italian dressing, commercial, regular	14.7	1 tbsp	1
04021	Salad dressing, italian dressing, reduced fat	15	1 tbsp	2
04025	Salad dressing, mayonnaise, soybean oil, with salt	13.8	1 tbsp	3
04015	Salad dressing, russian dressing	15.3	1 tbsp	3
04022	Salad dressing, russian dressing, low calorie	16.3	1 tbsp	6
04023	Salad dressing, thousand island dressing, reduced fat	15.3	1 tbsp	2
04017	Salad dressing, thousand island, commercial, regular	15.6	1 tbsp	4
07069	Salami, cooked, beef and pork	56.7	2 slices	108
07072	Salami, dry or hard, pork, beef	20	2 slices	28
02047	Salt, table	6	1 tsp	0
07073	Sandwich spread, pork, beef	15	1 tbsp	9
06150	Sauce, barbecue	15.75	1 tbsp	3
06930	Sauce, cheese, ready-to-serve	63	1/4 cup	99
06175	Sauce, hoisin, ready-to-serve	16	1 tbsp	6
06166	Sauce, homemade, white, medium	250	1 cup	245
06931	Sauce, pasta, spaghetti/marinara, ready-to-serve	250	1 cup	90
06168	Sauce, ready-to-serve, pepper or hot	4.7	1 tsp	1
06164	Sauce, salsa, ready-to-serve	16	1 tbsp	5
06112	Sauce, teriyaki, ready-to-serve	18	1 tbsp	28
11439	Sauerkraut, canned, solids and liquids	236	1 cup	47
07083	Sausage, Vienna, canned, chicken, beef, pork	16	1 sausage	8
11445	Seaweed, kelp, raw	10	2 tbsp	4
11667	Seaweed, spirulina, dried	0.93	1 tbsp	1
12516	Seeds, pumpkin and squash seed kernels, roasted, with salt added	28.35	1 oz (142 seeds)	332
12166	Seeds, sesame butter, tahini, from roasted and toasted kernels (most common type)	15	1 tbsp	110
12201	Seeds, sesame seed kernels, dried (decorticated)	8	1 tbsp	53
12537	Seeds, sunflower seed kernels, dry roasted, with salt added	32	1/4 cup	370
12537	Seeds, sunflower seed kernels, dry roasted, with salt added	28.35	1 oz	327
14346	Shake, fast food, chocolate	333	16 fl oz	340
14347	Shake, fast food, vanilla	333	16 fl oz	326
11677	Shallots, raw	10	1 tbsp	6
19097	Sherbet, orange	74	1/2 cup	30
04031	Shortening, household, soybean (hydrogenated)-cottonseed (hydrogenated)	12.8	1 tbsp	0

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19410	Snack, potato chips, made from dried potatoes, plain	28.35	1 oz	35
19002	Snacks, beef jerky, chopped and formed	19.8	1 large piece	81
19004	Snacks, corn-based, extruded, chips, barbecue-flavor	28.35	1 oz	59
19003	Snacks, corn-based, extruded, chips, plain	28.35	1 oz	45
19008	Snacks, corn-based, extruded, puffs or twists, cheese-flavor	28.35	1 oz	36
19013	Snacks, fruit leather, pieces	28.35	1 oz	7
19014	Snacks, fruit leather, rolls	21	1 large	7
19015	Snacks, granola bars, hard, plain	28.35	1 bar	79
19026	Snacks, granola bars, soft, coated, milk chocolate coating, peanut butter	28.35	1 bar	64
19404	Snacks, granola bars, soft, uncoated, chocolate chip	28.35	1 bar	50
19022	Snacks, granola bars, soft, uncoated, raisin	28.35	1 bar	62
19441	Snacks, KELLOGG, KELLOGG'S NUTRI-GRAIN Cereal Bars, fruit-filled	37	1 bar	38
19438	Snacks, KELLOGG, KELLOGG'S RICE KRISPIES TREATS Squares	22	1 bar	9
19031	Snacks, oriental mix, rice-based	28.35	1 oz (about 1/4 cup)	74
19034	Snacks, popcorn, air-popped	8	1 cup	29
19036	Snacks, popcorn, cakes	10	1 cake	28
19038	Snacks, popcorn, caramel-coated, with peanuts	42	1 cup	53
19039	Snacks, popcorn, caramel-coated, without peanuts	35.2	1 cup	29
19040	Snacks, popcorn, cheese-flavor	11	1 cup	40
19035	Snacks, popcorn, oil-popped, microwave, regular flavor	11	1 cup	22
19041	Snacks, pork skins, plain	28.35	1 oz	24
19042	Snacks, potato chips, barbecue-flavor	28.35	1 oz	53
19045	Snacks, potato chips, made from dried potatoes, reduced fat	28.35	1 oz	37
19046	Snacks, potato chips, made from dried potatoes, sour-cream and onion-flavor	28.35	1 oz	48
19411	Snacks, potato chips, plain, salted	28.35	1 oz	44
19811	Snacks, potato chips, plain, unsalted	28.35	1 oz	47
19422	Snacks, potato chips, reduced fat	28.35	1 oz	55
19043	Snacks, potato chips, sour-cream-and-onion-flavor	28.35	1 oz	50
19047	Snacks, pretzels, hard, plain, salted	60	10 pretzels	68
19033	Snacks, RALSTON PURINA, CHEX MIX	28.35	1 oz (about 2/3 cup)	44
19051	Snacks, rice cakes, brown rice, plain	9	1 cake	32
19057	Snacks, tortilla chips, nacho cheese	28.35	1 oz	73
19424	Snacks, tortilla chips, nacho-flavor, reduced fat	28.35	1 oz	90
19056	Snacks, tortilla chips, plain, white corn	28.35	1 oz	57
19062	Snacks, trail mix, regular, with chocolate chips, salted nuts and seeds	146	1 cup	565
19061	Snacks, trail mix, tropical	140	1 cup	260
06007	Soup, bean with ham, canned, chunky, ready-to-serve	243	1 cup	143
06404	Soup, bean with pork, canned, prepared with equal volume water	253	1 cup	121
06075	Soup, beef broth or bouillon, powder, dry	6	1 packet	19
06432	Soup, beef broth, bouillon, consomme, prepared with equal volume water	241	1 cup	31
06409	Soup, beef noodle, canned, prepared with equal volume water	244	1 cup	46
06419	Soup, chicken noodle, canned, prepared with equal volume water	241	1 cup	41
06528	Soup, chicken noodle, dry, mix, prepared with water	252.3	1 cup	30
06024	Soup, chicken vegetable, chunky, canned, ready-to-serve	240	1 cup	106
06423	Soup, chicken with rice, canned, prepared with equal volume water	241	1 cup	22
06018	Soup, chunky chicken noodle, canned, ready-to-serve	240	1 cup	151

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06067	Soup, chunky vegetable, canned, ready-to-serve	240	1 cup	72
06428	Soup, clam chowder, manhattan, canned, prepared with equal volume water	244	1 cup	39
06230	Soup, clam chowder, new england, canned, prepared with equal volume low fat (2%) milk	248	1 cup	432
06216	Soup, cream of chicken, canned, prepared with equal volume milk	248	1 cup	151
06416	Soup, cream of chicken, canned, prepared with equal volume water	244	1 cup	37
06243	Soup, cream of mushroom, canned, prepared with equal volume low fat (2%) milk	248	1 cup	154
06443	Soup, cream of mushroom, canned, prepared with equal volume water	244	1 cup	32
06440	Soup, minestrone, canned, prepared with equal volume water	241	1 cup	55
06094	Soup, onion, dry, mix	39	1 packet	82
06494	Soup, onion, dry, mix, prepared with water	246	1 cup	22
06449	Soup, pea, green, canned, prepared with equal volume water	250	1 cup	118
06174	Soup, stock, fish, home-prepared	233	1 cup	130
06359	Soup, tomato, canned, prepared with equal volume low fat (2%) milk	248	1 cup	156
06559	Soup, tomato, canned, prepared with equal volume water, commercial	244	1 cup	34
06471	Soup, vegetable beef, canned, prepared with equal volume water	244	1 cup	39
06468	Soup, vegetarian vegetable, canned, prepared with equal volume water	241	1 cup	34
01058	Sour dressing, non-butterfat, cultured, filled cream-type	12	1 tbsp	10
16123	Soy sauce made from soy and wheat (shoyu)	16	1 tbsp	20
11451	Soybeans, green, cooked, boiled, drained, without salt	180	1 cup	284
16109	Soybeans, mature cooked, boiled, without salt	172	1 cup	421
16120	Soy milk, original and vanilla, unfortified	245	1 cup	127
22401	Spaghetti with meat sauce, frozen entree	283	1 package	139
20121	Spaghetti, cooked, enriched, without added salt	140	1 cup	81
20125	Spaghetti, whole-wheat, cooked	140	1 cup	125
02007	Spices, celery seed	2	1 tsp	11
02009	Spices, chili powder	2.6	1 tsp	8
02010	Spices, cinnamon, ground	2.3	1 tsp	1
02015	Spices, curry powder	2	1 tsp	7
02020	Spices, garlic powder	2.8	1 tsp	12
02026	Spices, onion powder	2.1	1 tsp	7
02027	Spices, oregano, dried	1.5	1 tsp	3
02028	Spices, paprika	2.1	1 tsp	7
02029	Spices, parsley, dried	1.3	1 tbsp	5
02030	Spices, pepper, black	2.1	1 tsp	4
11658	Spinach souffle	136	1 cup	192
11461	Spinach, canned, drained solids	214	1 cup	94
11458	Spinach, cooked, boiled, drained, without salt	180	1 cup	101
11464	Spinach, frozen, chopped or leaf, cooked, boiled, drained, without salt	190	1 cup	95
11457	Spinach, raw	30	1 cup	15
11457	Spinach, raw	10	1 leaf	5
11642	Squash, summer, all varieties, cooked, boiled, drained, without salt	180	1 cup	70
11641	Squash, summer, all varieties, raw	113	1 cup	43
11644	Squash, winter, all varieties, cooked, baked, without salt	205	1 cup	39
11488	Squash, winter, butternut, frozen, cooked, boiled, without salt	240	1 cup	34
09320	Strawberries, frozen, sweetened, sliced	255	1 cup	33
09316	Strawberries, raw	12	1 strawberry	3

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09316	Strawberries, raw	18	1 strawberry	4
09316	Strawberries, raw	166	1 cup	40
19334	Sugars, brown	3.2	1 tsp	0
19335	Sugars, granulated	4.2	1 tsp	0
19336	Sugars, powdered	8	1 tbsps	0
11647	Sweet potato, canned, syrup pack, drained solids	196	1 cup	49
11512	Sweet potato, canned, vacuum pack	255	1 cup	125
11508	Sweet potato, cooked, baked in skin, without salt	146	1 potato	79
11510	Sweet potato, cooked, boiled, without skin	156	1 potato	50
11659	Sweet potato, cooked, candied, home-prepared	105	1 piece	27
18356	Sweet rolls, cinnamon, commercially prepared with raisins	60	1 roll	46
18358	Sweet rolls, cinnamon, refrigerated dough with frosting, baked	30	1 roll	104
19348	Syrups, chocolate, fudge-type	19	1 tbsps	18
19350	Syrups, corn, light	20	1 tbsps	0
19353	Syrups, maple	20	1 tbsps	0
19129	Syrups, table blends, pancake	20	1 tbsps	2
19128	Syrups, table blends, pancake, reduced-calorie	15	1 tbsps	6
18360	Taco shells, baked	13.3	1 medium	30
09223	Tangerine juice, canned, sweetened	249	1 cup	35
09220	Tangerines, (mandarin oranges), canned, light syrup pack	252	1 cup	25
09218	Tangerines, (mandarin oranges), raw	84	1 tangerine	17
20068	Tapioca, pearl, dry	152	1 cup	11
14355	Tea, brewed, prepared with tap water	178	6 fl oz	2
14545	Tea, herb, chamomile, brewed	178	6 fl oz	0
14381	Tea, herb, other than chamomile, brewed	178	6 fl oz	0
14376	Tea, instant, sweetened with sodium saccharin, lemon-flavored, prepared	237	8 fl oz	2
14371	Tea, instant, sweetened with sugar, lemon-flavored, without added ascorbic acid, powder, prepared	259	8 fl oz	0
14367	Tea, instant, unsweetened, powder, prepared	237	8 fl oz	2
18361	Toaster pastries, brown-sugar-cinnamon	50	1 pastry	67
18362	Toaster pastries, fruit (includes apple, blueberry, cherry, strawberry)	52	1 pastry	37
18482	Toaster Pastries, KELLOGG, KELLOGG'S POP TARTS, Frosted chocolate fudge	52	1 pastry	44
16126	Tofu, firm, prepared with calcium sulfate and magnesium chloride (nigari)	81	1/4 block	98
16127	Tofu, soft, prepared with calcium sulfate and magnesium chloride (nigari)	120	1 piece	110
11954	Tomatillos, raw	34	1 medium	13
11540	Tomato juice, canned, with salt added	243	1 cup	44
11546	Tomato products, canned, paste, without salt added	262	1 cup	217
11547	Tomato products, canned, puree, without salt added	250	1 cup	100
11549	Tomato products, canned, sauce	245	1 cup	64
11531	Tomatoes, red, ripe, canned, packed in tomato juice	240	1 cup	46
11533	Tomatoes, red, ripe, canned, stewed	255	1 cup	51
11529	Tomatoes, red, ripe, raw, year round average	180	1 cup	43
11529	Tomatoes, red, ripe, raw, year round average	17	1 cherry tomato	4
11529	Tomatoes, red, ripe, raw, year round average	123	1 tomato	30
11529	Tomatoes, red, ripe, raw, year round average	20	1 slice	5
11955	Tomatoes, sun-dried	2	1 piece	7

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11956	Tomatoes, sun-dried, packed in oil, drained	3	1 piece	4
18363	Tortillas, ready-to-bake or -fry, corn	26	1 tortilla	82
18364	Tortillas, ready-to-bake or -fry, flour	32	1 tortilla	40
21088	Tostada with guacamole	130.5	1 tostada	116
05286	Turkey and gravy, frozen	142	5-oz package	115
05292	Turkey patties, breaded, battered, fried	64	1 patty	173
05296	Turkey roast, boneless, frozen, seasoned, light and dark meat, roasted	85.05	3 oz	208
05188	Turkey, all classes, dark meat, cooked, roasted	84	3 oz	171
05172	Turkey, all classes, giblets, cooked, simmered, some giblet fat	145	1 cup	335
05186	Turkey, all classes, light meat, cooked, roasted	84	3 oz	184
05168	Turkey, all classes, meat only, cooked, roasted	140	1 cup	298
05180	Turkey, all classes, neck, meat only, cooked, simmered	152	1 neck	185
11569	Turnip greens, cooked, boiled, drained, without salt	144	1 cup	42
11575	Turnip greens, frozen, cooked, boiled, drained, without salt	164	1 cup	56
11565	Turnips, cooked, boiled, drained, without salt	156	1 cup	41
02050	Vanilla extract	4.2	1 tsp	0
17095	Veal, leg (top round), separable lean and fat, cooked, braised	85	3 oz	212
17112	Veal, rib, separable lean and fat, cooked, roasted	85	3 oz	167
11578	Vegetable juice cocktail, canned	242	1 cup	41
11581	Vegetables, mixed, canned, drained solids	163	1 cup	68
11584	Vegetables, mixed, frozen, cooked, boiled, drained, without salt	182	1 cup	93
02048	Vinegar, cider	15	1 tbsp	1
18403	Waffles, plain, frozen, ready -to-heat, toasted	33	1 waffle	142
18367	Waffles, plain, prepared from recipe	75	1 waffle	143
14429	Water, tap, municipal	237	8 fl oz	0
11590	Waterchestnuts, chinese, canned, solids and liquids	140	1 cup	27
09326	Watermelon, raw	286	1 wedge	31
09326	Watermelon, raw	152	1 cup	17
20081	Wheat flour, white, all-purpose, enriched, bleached	125	1 cup	135
20082	Wheat flour, white, all-purpose, self-rising, enriched	125	1 cup	744
20083	Wheat flour, white, bread, enriched	137	1 cup	133
20084	Wheat flour, white, cake, enriched	137	1 cup	116
20080	Wheat flour, whole-grain	120	1 cup	415
20089	Wild rice, cooked	164	1 cup	134
01121	Yogurt, fruit, low fat, 10 grams protein per 8 ounce	227	8-oz container	270
01117	Yogurt, plain, low fat, 12 grams protein per 8 ounce	227	8-oz container	327
01118	Yogurt, plain, skim milk, 13 grams protein per 8 ounce	227	8-oz container	356
01116	Yogurt, plain, whole milk, 8 grams protein per 8 ounce	227	8-oz container	216